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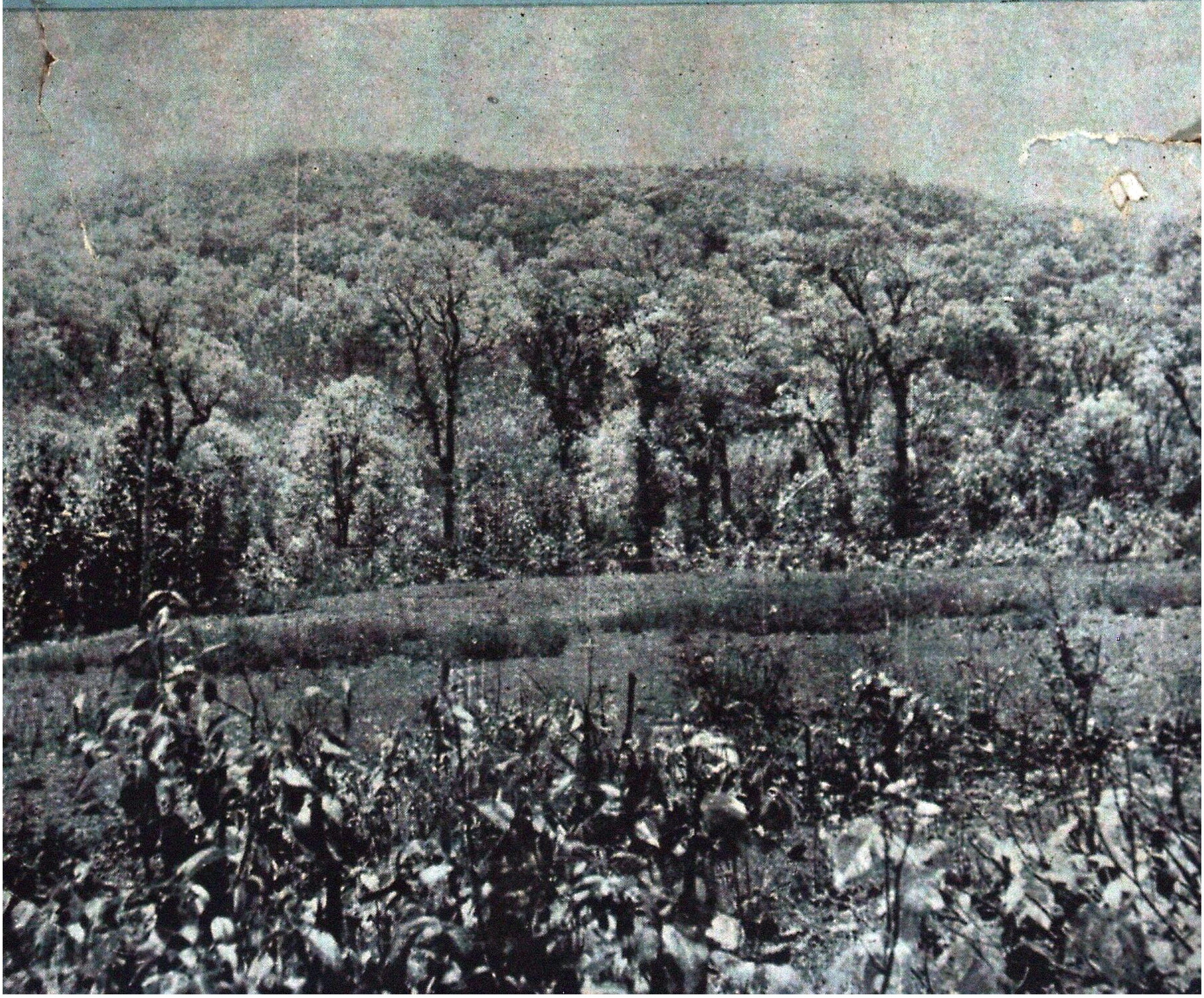

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PRIMARY PRODUCTION OF A DECIDUOUS FOREST AT VARANASI

R.P. SINGH* AND O.P. CHATURVEDI**

Introduction

The term 'production' in general may be considered as the rate of net primary production of organic matter left after respiration but including all losses from litter fall, grazing, etc. (Egunjobi, 1969). Ovington (1962) has clearly distinguished "mean annual net productivity" obtained by averaging the biomass over the age of the stand, and the "current annual net productivity", which is the current rate of organic matter production. The latter measurement is considered more useful in the estimations of biological productivity.

The study site is situated at lat. 24.42 to 25.50 long. 83.22 to 83.40 on the Vindhyan hills and plateaux (elevation about 300 m above m.s.l.) in the Naugarh block of Varanasi forests. It is a reserved forest but is exposed to human pressure on account of immigration and grazing in the area, very often politically motivated. The terrain is well drained with a monsoon rainfall of about 750 mm and rest about 250-300 mm falling in the drier months. Winter is mild but May and June are driest with the maximum temperature rising to 48°C. Hot dusty winds provide input of undetermined amounts of nutrients just as the monsoon showers do. One of our estimates puts calcium and nitrogen input of 23 and 51 kg ha^{-1} $year^{-1}$ respectively through rains (Misra, 1970). Losses through leaching and run off to the ecosystem may also be considerable. The soils are shallow and bright red.

The forest is dominated by *Shorea robusta*, *Madhuca indica*, *Buchanania lanzan*, *Diospyros melanoxylon* and *Terminalia tomentosa*. There are twenty one more tree species of lesser frequency. The highest, thickest and oldest trees are about 15 m tall but they are fewer in number. There is a gradient of stratification with the younger trees which are far more dense. Hence, the second and only other distinct layer consists of the herbs and shrubs. The canopy is almost closed except for the hot summer period when the leaves are shed and ground vegetation dries up.

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Methods

The five above named dominant species and one minor tree species namely *Semicarpus anacardium* were chosen for detailed analysis by selective harvesting. Three trees, each of available girth classes 10-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90 and 91-100 cm cbh (circumference at breast height) of each of the species, which were felled for morphomatric measurements and determination of bole, branches, leaves and roots fresh weight and dry weight by aliquot sampling as described by Newbould (1967). At the same time in February-March, 1971 a number of standing trees of median girth within each class of each of the species were marked for measurement of girth increment over one year in 1972. Besides these the entire population of all the 26 species was evaluated on quadrat basis individually for their density and girth. The mean values obtained from the six species were projected for the other 20 species for the rest of the measurements.

Bivariate allometric regression analysis of the data established relationships between girth and biomass besides showing a high correlation coefficient between girth and height, and biomass of different fractions of each of the tree species. Hence, girth and total biomass are considered in subsequent calculations for annual productivity. The girth and age relationships are described elsewhere paper (Mishra *et al.*, 1974).

The results are expressed in terms of mean annual net productivity (MANP) by dividing the total biomass by the age of the tree and current annual net productivity (CANP) by calculating the biomass increment during the year 1971-72. Since there happened to be a large difference between the two types of estimates the cumulative annual foliage output per tree through its age was also determined by mathematical modelling and computer analysis for total net production

Results and Discussion

The data are summarised in Table 1 for the annual productivity as found by the two methods for three principal tree species. The standing biomass, the current annual net productivity and the annual increment as percentage of the standing biomass of the whole stand is given in Table 2.

The data which are not given for brevity indicate a proportionate fractionation of the biomass in the different parts of the trees. The maximum being in the bole and the minimum in the leaves which however expose much surface area. *Diospyros melanoxylon* shows a higher proportion in the roots on account of strong vegetative sprouting through root suckers. It is a well known phenomenon that trees like species of *Ficus* being mesic in character which regenerate aerially and hence have a higher proportion of the biomass above ground whereas those regenerating from below the ground are xeric in character. Tables 3 gives the ratio of root and undershoot biomass of the six tree species and they seem to fit in a meso-xeric gradient characteristic of semi-humid areas. The root and shoot ratio values (0.132-0.303) reported by Foruqi (1972) and Singh (1979) lies in the present range (0.11-0.64).

Table 1

Comparative statement of CANP and MANP (kg tree^{-1} yr^{-1}, on cumulative basis) of three dominant species of a deciduous forest at Varanasi.

Cbh size (cm)	*Shorea robusta*		*Madhuca indica*		*Buchanania lanzan*	
	CANP	MANP	CANP	MANP	CANP	MANP
15.0	2.30	1.17	2.88	1.21	1.98	0.82
25.0	4.43	1.87	2.82	2.12	2.53	1.32
35.0	6.18	3.02	10.44	2.98	3.79	1.84
45.0	7.19	4.24	12.52	5.50	4.91	2.63
55.0	12.45	5.88	12 21	6.42	7.37	3 82
65.0	18.50	7 09	18.66	8.45	7.82	3.76
75.0	14.70	9.49	22.19	11.03	9.85	5.98
85.0	20.72	11.95	21.54	12.25	12.44	6.58
95.0	23.35	14.09	26.14	14.35	13.53	7.43

Table 2

Standing biomass, current annual net productivity and per cent annual increment of the standing biomass of the total stand

Cbh range (cm)	Species	Biomass: Total biomass (kg ha^{-1})	Biomass: Photo-synthetic biomass (kg ha^{-1})	Current annual net productivity (kg ha^{-1} yr^{-1})	Annual increment as % of total biomass (%)	Annual increment of biomass of the total stand biomass: Total increment (%)	Photo-synthetic increment (%)	Non photo-synthetic increment (%)
15–95	*Shorea robusta*	14294.00	331.70	1451.96	12.38			
15–95	*Madhuca indica*	13176.37	901.09	1267.15	9.61			
15–95	*Buchanania lanzan*	8009.70	914.59	623.18	8.99	9.97	6.68	3.29
15—45	*Diospyros melanoxylon*	1778.05	184.19	363 30	20.43			
15—55	*Terminalia tomentosa*	3898.37	206.05	407.29	10.44			
15–35	*Semicarpus anacardium*	794.90	67 72	108.78	1.36			
10—83	Other species	11924.84	998 45	1152.80	9.67			
	Total stand	53876.23	3603.79	5374.46	—			

Table 1 clearly demonstrates that the usual method of finding out mean annual net production by dividing the biomass by the age of the tree as employed by foresters in estimating wood production, does not give the complete organic productivity. The values are less than half of the current annual net productivity even when computations are made for the cumulative crops of annual leaves through the age of the tree for giving weightage to MANP. Species vary in their CANP depending upon the differences in total biomass at a given age. The difference becomes more obvious as the trees mature. Similar fluctuations in the values of mean annual production have been shown by Ovington (1962) for *Pinus sylvestris* and Satyanarayan (1972) for *Shorea robusta* plantations.

Table 2 is based on one hectare sample of the stand and is highly based on the density of the different populations. Hence the importance of the productive structure of a forest which has been very often ignored by a large number of workers. Nevertheless, it is clear that on area basis the annual productivity of photosynthetic biomass is almost double the non photosynthetic biomass and that *Diospyros melanoxylon* bearing the minimum standing crop, adds maximum biomass annually to the ecosystem (20. 43%). The standing crop of the forest is roughly 53.8 tons per hectare. If estimates are made for the ground vegetation of herbs and also of trees thinner then 10 cm girth, the total may go upto 75 tons per hectare.

Table 3

Root/Shoot Ratio of six dominant tree species of different girths of Chakia forest Varanasi

Girth (cm)	*Shorea robusta*	*Madhuca indica*	*Buchanania lanzan*	*Diospyros melanoxylon*	*Terminalia tomentosa*	*Semicarpus anacardium*
15.0	0.30	0.24	0.28	0.21	0.55	0.46
25 0	0.26	0.22	0.16	0.33	0.36	0.64
35.0	0.28	0.11	0.14	0.23	0.30	0.52
45.0	0.30	0.21	0.19	0.47	0.32	—
55.0	0.22	0.16	0.12	—	0.26	—
65.0	0.22	0.17	0.14	—	—	—
75.0	0.19	0.17	0.13	—	—	—
85.0	0.27	0.18	0 16	—	—	—
95.0	0.28	0.16	0.15	—	—	—

Desh Bandhu (1971) has given an estimate of about 240 tons ha^{-1} of stand biomass of an *Anogeissus latifolia – Shorea robusta* forest constituted of 16 species only. He believes that the forest is about 40 years old hence the mean annual net productivity will be about 6 tons ha^{-1} against 5.4 tons ha^{-1} for the present study. So the ratio of annual productivity to standing biomass is much higher at the present site and it bears some relationship with the age of the forest rather than with the diversity of species. It is therefore concluded that the site under study bears a comparatively young forest although some of the trees may be a little more than 100 years old.

Acknowledgement

We are grateful to Prof. R. Misra, Ex Head, Department of Botany, Banaras Hindu University for supervising the research work.

SUMMARY

Primary productivity of six principal tree species constituting 65,1% of tree population and about 80% of the basal area of tree is examined for individual tree, species and density and area basis. The results are extrapolated to the remaining 20 species of the community. The method employed is based on harvesting of selected trees of different girth and measuring increment in girth of marked trees for a period of one year Mathematical models of increment in girth and corresponding biomass have been developed to estimate mean annual net productivity and the current annual net productivity. Age of the trees in the natural stand was determined from regression analysis. It is shown that the method employed in forestry for determination of wood volume on the basis of mean and current prodvctivities, grossly underestimates total productivity of the forest.

वाराणसी के पर्णपाती वन का प्राथमिक उत्पादन

लेखक आर०पी० सिंह व ओ०पी० चतुर्वेदी

सारांश

अलग-अलग वृक्ष जातियों तथा घनत्व और क्षेत्रफल के आधार पर छह प्रमुख वृक्ष जातियों की, जो कुल वृक्ष संख्या का 65.1% तथा कुल वृक्ष आधार क्षेत्रफल का लगभग 80% है, प्राथमिक उत्पादकता की जांच पड़ताल की गई है। प्राप्त हुए परिणामों को वृक्ष समुदाय की अवशिष्ट 20 जातियों पर बहिर्वेशित किया गया। इसके लिए प्रयुक्त की गई रीति विभिन्न गोलाइयों के चुने हुए वृक्षों की कटाई करने तथा एक बर्ष की अवधि के लिए चिह्नित किए हुए वृक्षों की गोलाई में हुई संवृद्धि की है। शुद्ध माध्य उत्पादकता और शुद्ध साम्प्रत् वार्षिक उत्पादकता का अनुमान लगाने के लिए गोलाई में हुई संवृद्धि और उससे संबद्ध जैवपुंज के गणितीय प्रतिरूप (मॉडल) विकसित किए गए हैं। प्राकृतिक वृक्ष समूह में खड़े वृक्षों की वयस प्रतीपायन विश्लेषण द्वारा विनिश्चित की गई। दिखलाया यह गया है कि वानिकी में माध्य और साम्प्रत् उत्पादकताओं के आधार पर काष्ठ आयतन विनिश्चित करने की रीति द्वारा वन की सम्पूर्ण उत्पादकता के अनुमान बहुत अधिक घट कर प्राप्त होते हैं।

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INTERCEPTION STUDIES IN *CEDRUS DEODARA* LOUDON PLANTATION IN HIMACHAL PRADESH

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Introduction

The influence of the vegetative canopy on precipitation interception is a matter of common experience when one stands below the canopy of a tree during the first shower of the rainfall and keeps himself dry. Precipitation is caught by the vegetative canopy and redistributed as throughfall, stemflow and evaporation from the vegetation. Hamilton and Rowe (1949) have used a number of terms to describe the various components in the process of interception. In general, interception is the difference between the precipitation measured in open and under the vegetation cover.

Interception is an important part of the hydrological cycle which affects the movements of water in the soil, moisture budget of the soil and run-off which in turn has the influence on soil erosion and floods etc. A number of interception studies have been conducted by different workers in India as well as abroad under different canopy cover (Hamilton & Rowe, 1949; K tteredge, 1948; Voigt, 1960; Dabral and Prem Nath, 1962; Dabral and Subba Rao, 1968, 1969; George, 1978 and Ghosh *et al.*, 1980). In India, most of the work has been done on broad leaved species, although, Dabral and Subba Rao (1968), have conducted interception studies on Chir also, as a consequence an attempt was made to conduct interception studies in *Cedrus deodara* plantation and the methodology adopted and results obtained are discussed in this paper.

Description of the Stand and Experimental site

Interception studies were carried out in *Cedrus deodara* Loudon, plantation at Shillaroo (31°13′ 45″ N, 77°26′ 48″ E), Kotgarh Forest Division of Simla District (Himachal Pradesh), 55 km from Simla on Simla-Narkanda road at 2400 m elevation above the mean sea level. The soil is clay loam and silt clay loam having pebbles and stones at depths varying from 1-2 m. The preliminary data on the *Cedrus deodara* plantation is given in Table 1. Climatological data of this site is available for only two years when this station came into existence and installed its own observatory. The average value of two years climatological data is presented in Table 2.

Table 1

Preliminary data on Cedrus deodara plantation in Kotgarh Forest Division at Shillaroo (H.P.)

1.	Area of the study plot	0.049 ha
2.	Age of the plantation	35 years (Approx.)
3.	Average spacing	4 × 5 m
4.	No. of trees in the plantation/ha	515
5.	Average	
	D.B.H.	28.8 cm
	Height	16.16 m
6.	Crown density	94.53%

Table 2

Mean monthly Rainfall, Humidity and Temperatures (Average of 2 years) (1980-81) of Shillaroo (H.P.)

Months	Rainfall in mm	Relative	Humidity%	Temperature °C		
		08.30 hrs	14.00 hrs	Max.	Min.	Mean
January	—	61.05	56.85	9.40	2.30	5.85
February	5.35	56.40	55.00	10.16	2.73	6.44
March	70.05	60.55	57.60	11.15	4.27	7.71
April	37.00	46.15	41.90	18.32	10.19	14.26
May	60.53	50.10	49.20	20.18	12.63	16.41
June	161.15	67.50	61.85	23.51	16.30	19.90
July	325.95	93.70	90.40	21.75	16.12	18.91
August	204.15	87.60	82.50	21.74	16.13	18.94
September	46.85	75.90	71.05	21.60	14.27	17.93
October	8.55	57.35	50.40	19.35	10.91	15.19
November	—	65.05	55.70	15.92	7.02	11.45
December	—	55.10	51.00	13.36	5.26	9.30
Average	919.58	64.70	60.29	17.20	9.84	13.52

Materials and Methods

The present study was started in September, 1979 at Shillaroo and continued upto August, 1981. All the trees in the plantation were numbered and their diameter at breast height was measured. The breast height diameter of the trees ranged from 15.0 cm to 45.0 cm. The trees were grouped under three diameter classes of 10.0 cm interval and details are given in Table 3.

Table 3

Distribution of trees in the interception plot under diameter classes in Cedrus deodara plantation.

Diameter class (cm)	No. of Trees	No. of trees fitted with collar
15—25	51	5
25—35	104	11
35—45	33	4
Total :	188	20

Thus, a total of 20 trees were taken up for stemflow measurements with the help of metal collars, fitted at breast height, having one metal outlet tube of suitable diameter and length at the base of each collar for water to flow out. Each outlet was connected with a rubber tube of suitable length for collecting the stemflow in empty tins (23.5 × 23.5 × 35.0 cm), which were covered with tin sheet to check direct rain falling into the containers. At the time of collar fittings and also at different times, it was ensured by making the collar water-tight at the base with the help of putty that no water leaked out from the collar. Throughfall was collected in eighty empty tins (same size as above) placed at random in the area chosen for the study, The water collected in stemflow and throughfall tins was measured after each storm with the help of measuring cylinder and funnel, the quantity of water measured in litres was converted into mm depth and later on for the study area by computation. A raingauge was installed in an open plot near the experimental plot for measuring the rainfall without any interception.

Results and Discussions

Throughfall, stemflow and interception of precipitation on monthly basis for the period from September, 1979 to August, 1981 in *Cedrus deodara* plantation both in terms of quantity and percentage of the total rainfall is given in Table 4. It is clear from the data that the quantity of stem flow is lower in comparison to that of throughfall for the whole period of the study. Of the total rainfall (1850.10 mm), 1328.506 mm (71.81%) was throughfall, 55.363 mm (2.99%) stemflow and 466.224 mm (25.20%) interception respectively.

The maximum interception of rainfall (69.10%) was recorded in February, 1980 which had the lowest (7.00 mm) rainfall, while the minimum interception (18.71%) was obtained in July, 1980, the month which had the maximum (370.20 mm) rainfall. In case of maximum interception in the month of February, 1980, Throughfall percentage (30.90%) was minimum and stemflow was nil. On the other hand, in the month of July, 1980, which had the minimum interception and maximum rainfall, the throughfall percentage (76.74%) and stemflow percentage (4.54%) were maximum respectively. Interception loss decreased with the increasing amount of rainfall.

Table 4

Throughfall, stemflow and interception loss in Cedrus deodara plantation.

Year & Months	Total rainfall (mm)	Throughfall (mm)	Throughfall (%)	Stemflow (mm)	Stemflow (%)	Stemflow + Throughfall (mm)	Interception loss (mm)	Interception (%)
1979								
Sept.	63.80	39.632	62.12	0.610	0.96	40.242	23.558	36.92
Oct.	—	—	—	—	—	—	—	—
Nov.	18.80	9.305	49.49	0.024	0.13	9.329	9.471	50.37
Dec.	—	—	—	—	—	—	—	—
1980								
Jan.	—	—	—	—	—	—	—	--
Feb.	7.00	2.163	30.90	0 00	0.00	2.163	4.837	69.10
Mar.	39.50	23.850	60.38	0.103	0.26	23.953	15.547	39.35
Apr.	31.40	18.320	58.34	0.115	0.37	18.435	12.965	41 28
May	13.30	4·722	35.50	0.011	0.08	4 733	8 567	64.41
June	229.70	173 916	75.71	8.958	3.90	182.874	46.826	20.38
July	370.20	284.094	76.74	16.807	4.54	300.901	69.299	18.71
Aug.	214.10	164.474	76.82	7.964	3.72	172 438	41.662	19.45
Sept.	39.10	23.389	59.82	0.163	0.42	23.552	15 548	39 76
Oct.	16.80	9.552	56.86	0.018	0.11	9.570	7.230	43.03
Nov.	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—	—	—	—
1981								
Jan.	—	—	—	—	—	—	—	—
Feb.	—	—	—	—	—	—	—	—
Mar.	88.60	56.358	63.61	1.532	1.73	57.890	30.710	34.66
Apr.	41.60	24.900	59.86	0·206	0.49	25.106	16.494	39.64
May	98.30	64.611	65.72	1.730	1.76	66.341	31.952	32.51
June	102.00	69.913	68.54	1.754	1.72	71.667	30.333	29.73
July	277.70	214.774	77.34	10.413	3.75	225.187	52.513	18.90
Aug.	198.20	144.533	72.92	4.955	2.50	149.488	48.712	24.58
Average	1850.100	1328.506	71.81	55.363	2.99	1383.869	466.224	25.20

The interception loss for the whole period of study ranged from 18.71 to 69.10%. Canopy withheld maximum interception during light showers and minimum in heavy showers. The amount of rainfall required to wet the vegetation depends largely on the intensity and duration of rainfall and number of rainy days. Coniferous trees intercept more rainfall than

deciduous trees in full leaf. The large number of small linear leaves in Conifers hinders the free flow of raindrops and presents numerous cavaties in which water can be trapped (Anon. 1964). Wisler and Brater (1959) concluded that far any given depth of precipitation, winter and summar losses appear to be about the same for conifers, but for deciduous trees summer losses are 2 or 3 times greater than winter losses. Trimble (1959) stated that a dense even-aged conifer stand will usually intercept about one-forth to more than one-third of the precipitation that falls, the more tolerant (thickers crowns) and stiffer-needled conifers intercepting a larger amount, Stemflow is less than 5% and depends on position of the tree in the canopy, smoothness of the bark, branching habit and season of the year. The results of the present study get significant support from the results of Wisler and Brater (1959) and Trimble (1959), The bark of the *Cedrus deodara* is rough and checks the flow of water running down along the stem. The amount of rain at which stemflow starts may be as low as 0.25 mm for smooth-bark species like Beech or as high as 1.75 mm for rough-bark species (Anon, 1964). In dense stand of spruce-fir forest, Anon, (1964) recorded 32.0% net interception loss and 3.0% stemflow respectively at the age of greatest interception loss. In present study, the *Cedrus deodara* intercepts 25.20% as the net interception of the total rainfall (1850.10 mm) and 2.99% as the stemflow (Table 4). Ghosh *et al.* (1980) have conducted interception studies in Sal coppice forest (crown density 88%) and observed 18.0% interception loss. George (1978) has estimated 11.5% interception loss in *Eucalyptus hybrid* (crown density 84%) plantation. Dabral and Rao (1968) have estimated 22% interception loss under Chir Pine (*Pinus roxburghii*) plantation having 3.6% stemflow and 74.3% throughfall.

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SUMMARY

The present investigations deal with the throughfall, stemflow and intercreption loss in *Cedrus deodara* Loudon plantation (94.5% crown density) of about 35 years age at Shillaroo, Kotgarh Forest Division, Distt. Simla (Himachal Pradesh). Of the total rainfall (1850.1 mm) 2.9% (55.3 mm) stemflow, 71.8% (1328.5 mm) throughfall and 25.2% (466.2 mm) interception loss were recorded respectively by for the whole study period. The minimum interception loss (18.7%) was observed in the month of July, 1980 which had the maximum (370 2 mm) rainfall. The highest interception (69.1%) was recorded in the month of February, 1980, which had the lowest (7.0 mm) rainfall. Interception loss was decreased with the increasing amount of precipitation.

हिमाचल प्रदेश में सीडरस डिओडारा लूडन के रोपवन में जलावरोधन का अध्ययन

लेखक आर०पी० सिंह, के०सी० शर्मा, एच०एन० माथुर, एम०के० गुप्त व ए०के० गुप्त

सारांश

प्रस्तुत अन्वेषण में शिलारू, कोटगढ़ वन मंडल, जि० शिमला (हि० प्र०) में लगे हुए लगभग 36 वर्ष उम्र के सीडरस डियोडारा लूडन के वन में प्रत्यक्ष पतन, स्तम्भ प्रवाह और जलावरोधन हानि की विवेचना की गई है। कुल वर्षा (1850.1 मिमी०) में अध्ययन की सम्पूर्ण अवधि के दौरान क्रमश: 2.9% (55.3 मिमी०) स्तम्भ प्रवाह, 71.8% (1328.5 मिमी०) प्रत्यक्ष पतन और 25.2% (466.2 मिमी० जलावरोधन हानि अभिलिखित किए गए। सबसे कम जलावरोधन हानि (18.7%) जुलाई 1980 महीने में होती देखी गई जिसमें वर्षा अधिकतम (370.2 मिमी०) हुई। अधिकतम जलावरोधन (69.1%) फरवरी 1980 महीने में देखा गया जिसमें वर्षा सबसे कम (7.0 मिमी०) हुई। वर्षा में वृद्धि होने के साथ जलावरोधन हानि घटती चली गई।

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PRELIMINARY STUDIES ON THE POPULATION DIFFERENTIATION IN *DACTYLOCTENIUM AEGYPTIUM* (LINN.) P. BEAUV. IN NIGERIA

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One of the commonest features in biotic life is the presence of variations. They are caused by several factors such as climate, soil altitude, etc. Many terms have been coined to define these variations. The concept of ecotypes has been well illustrated by Turesson (1922); Gregor (1946); Clausen (1951), and Clausen, Keck and Heisey (1940, 1948). Stapledon (1928) working on *Dactylis glomerata* recognised six ecological races (ecotypes) in Wales. There are many reports about ecotypes.

In Nigeria, there is only one species of *Dactyloctenium*, *D. aegyptium* (Linn.) P.Beauv. (Stanfied, 1970 and Townrow, 1959). *D. aegyptium* occurs naturally on waste lands, as a common weed in cultivated areas, pastures and along road sides. It is found from sea level to 2,000 m altitude in the tropics, subtropics and warm temperate regions, (Bogdan, 1977). It is a native of the Old World and a weed in 45 countries as a pest of peanuts, cotton, tea, coffee, maize and other crops (Holm, Plucknett, Panch and Herberger, 1977). It is an alternative host of viruses which cause rice leaf gall and corn gall (Agati and Calica, 1950).

It was noticed that there were three different forms of this species which were arbitrily designated forms A, B and C based on morphological differences (Table 1). Different workers (Clayton, 1972, Stanfield, 1970 and Townrow, 1959) have describad the plant differently.

Only Townrow mentions the maroon colouration of the spikes which we have also observed. It was, therefore, decided to undertake growth studies to find the sources of variation.

Materials and Methods

The study was conducted at the University of Ibadan Campus which has an area of 1032 hectares (University of Ibadan Calendar, 1978). Ibadan is situated at 03°54′ East longitude and 07°23′ North latitude in South-West Nigeria

(a) *Soil and Climate*

Standard methods were followed for the determination of soil moisture content, organic matter content and pH. (Chapman, 1976). The pH ranged from 6 2 to 6.9. Organic matter content varied from 2.03% to 2.3% while soil moisture ranged from 0.021% to 0 022%.

Temperature varied from 11.7°C minimum in January to 37.7°C maximum in February for the year 1978. The average mean daily temperature varied from 23.2°C in July to 30,2°C in Febrauy. The relative humidity was highest (89% to 95%) at 0700 hours but decreased (32% to 74%) at 1600 hours. The total rainfall over the year was 1578.5 mm (Fig. 1).

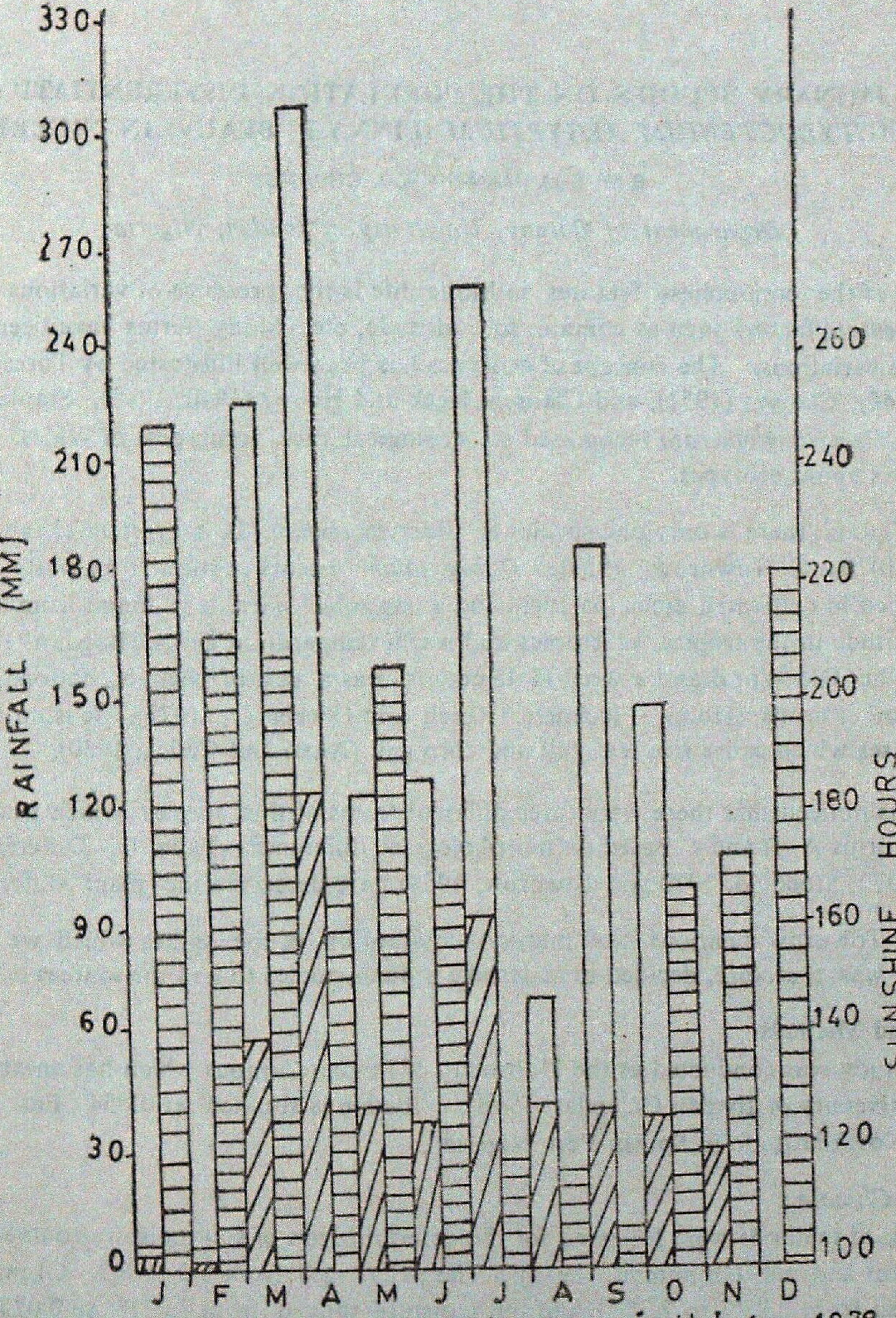


Fig. Rainfall and sunshine hours in U I for 1978.

Total rainfall. Most rainfall in one day.

Sunshine hours.

Table 1

Salient differences in the three forms of Dactyloctenium aegyptium growing in the University of Ibadan Campus, Nigeria

Parameter	Forms		
	A	B	C
1. Growth pattern	matforming	stoloniferous	erect and tufted
2. Maximum height	30 cm	50 cm	80 cm
3. Longest leaf	16 cm	25 cm	36 cm
4. Maximum spike length	3 cm	4 cm	6 cm
5. Spike colour	maroon	green	green
6. Seed colour	reddish brown	reddish brown	greyish brown

(b) *Cultural experiments*

1. *Growth studies in the field.* Very young plants of each form collected from the field were transplanted in soil gathered from the same places of collection and contained in claypots 20 cm wide and 18 cm deep placed in the glass-house. Three plants were planted in each pot and one week was allowed for establishment before readings were taken. Water was added regularly to keep the plants at field capacity. Morphological measurements were taken weekly. There were three replicates for each form.

2. *Determination of growth parameters* (Chapman, 1976).

(i) Relative water content (Wr) using the formula,

$$Wr = \frac{100\,(f-d)}{(s-d)} \quad \text{where,}$$

Wr = Relative water content.
f = Weight of shoot before immersion in water.
s = Weight of shoot after immersion in water.
d = Weight of shoot after drying in oven.

(ii) *Leaf area ratio* (LAR) using formula,

$$LAR = \frac{\text{Area of 10 leaves}}{\text{Dry weight of those 10 leaves}}$$

(iii) Leaf weight ratio (LWR) using the formula,

$$LWR = \frac{\text{Total weight of leaves}}{\text{Total dry weight of the whole plant}}$$

(iv) Mean relative growth rate $\bar{R}$ given by formula,

$$R = \frac{\ln(W2) - \ln(W1)}{t2 - t1} \quad \text{Where,}$$

W_2, W1 = Dry weights,

t2, t1 = Time interval of Six Weeks.

(v) Instantaneous growth rate (R) is given by formula,

$$R = \frac{1}{W} \cdot \frac{dw}{dt} \quad \text{where,}$$

W = dry weight

3. *Biomass Studies.* Three quadrats (50 × 50 cm) were placed at random in the sites where each of the forms was commonly found. All the plants enclosed by the quadrat were clipped at ground level and carried to the laboratory in a plastic bag. *Dactyloctenium aegyptium* plants were sorted out. The fresh and dry weights of *D. aegyptium* and the associated plants of each form were determined. Drying was done in an oven at 100°C for 24 hours. Biomass of *D. aegyptium* plants from the Glass House, Orchid House and open environment was also determined.

4. *Cytological Studies.* Root tips of three forms were collected from plants grown in the Glass House and chromosome numbers determined using the method of Olorode (1974).

Results and Discussion

The present investigation deals with the behaviour of three forms of *Dactyloctenium aegyptium* under tropical environment in Nigeria. It was to establish whether they are ecads or ecotypes. It was very much desirable to subject the three forms to the same kind of experimental conditions and observe their responses. Results of the various experiments are discussed below.

Growth behaviour in the field. The three forms behaved in more or less the same way, particularly in the number of leaves and leaf length However, the largest increase in the number of leaves was found in Form B and the least in Form A. Flowering period was distinctly different, with Form C flowering as early as in the 3rd week, while Form A flowered last during the 6th week. (Table 2.)

Growth behaviour in different environments. There was a general reduction in the growth of all the three forms when they were grown in the Orchid House (Table 3). However, the least growth was found in Form A with leaf increase of only 6 leaves over a period of 7 weeks.

Tiller increase in the various forms was minimal varying from 2—4 at the end of the experiment.

Reduced growth might be due to a lack of adequate light and some edaphic factors as relative humidity was comparatively higher. Wilsie (1962) noted that when conditions are note optimal for one factor the limit of tolerance may be reduced with respect to another factor. Also the period of reproduction is critical when environmental factors are likely to be limiting. The excess moisture combined with inadequate light may lead to delayed flowering, poor seed setting and generally poor growth. Even after the experimentation was over there was no flowering in Form A. The other two forms flowered, yet produced one or two spikes about 2 cm long against 4—7 spikes, 5—7 cm long found in field under natural conditions.

Table 2

Growth behaviour of Dactyloctenium aegyptium transplanted from the field to the Glass House in the pots containing field soil.

	Wk. 1	Wk. 2	Wk. 3	Wk. 4	Wk. 5	Wk. 6
Form A						
Number of leaves	15	16	22	35	34	30
Longest leaf (cm)	8	10	15	20	20	18
Number of tillers	2	2	3	5	5	5
Flowering period	—	—	—	—	—	fl
Number of spikes	—	—	—	—	3	4
Form B						
Number of leaves	10	20	30	40	42	39
Longest leaf (cm)	18	12	19	26	30	32
Number of tillers	3	3	4	6	6	6
Flowering period	—	—	—	—	fl	fl
Number of spikes	—	—	—	—	4	4
Form C						
Number of leaves	12	14	20	26	25	20
Longest leaf (cm)	12	14	20	33	34	28
Number of tillers	2	2	3	4	4	4
Flowering period	—	—	fl	fl	fl	fl
Number of spikes	—	—	4	5	4	4

Table 3

Growth behaviour of Dactyloctenium aegyptium in three different environments (4th Jan., to 23rd Feb., 1979)

		Open environment			Glass House			Orchid House		
Week		A	B	C	A	B	C	A	B	C
1	Number of leaves	4	4	4	4	5	3	4	3	4
	Longest leaf (cm)	15	12	12	13	19	9.5	10	8.5	12
	Number of tillers	1	1	1	1	1	1	1	1	1
	Cover (cm)	1	1	1	1	1	2	1	1	1
3	Number of leaves	84	36	49	16	21	12	4	6	4
	Longest leaf (cm)	22	30	24	36	38	30	14	20	14
	Number of tillers	7	6	7	4	3	2	1	1	1
	Cover (cm)	24	28	22	10	12	10	2	3	3
	Flowering period	—	—	—	—	—	—	—	—	fl
	Number of spikes	—	—	—	—	—	—	—	—	2
5	Number of leaves	140	112	98	42	70	25	4	8	14
	Longest leaf (cm)	20	20	24	25	50	48	14	22	20
	Number of tillers	12	10	7	7	7	5	2	3	4
	Cover (cm)	60	60	50	30	40	10	3	5	5
	Flowering period	fl	fl	fl	fl	fl	fl	—	fl	fl
	Number of spikes	3–5	3-5	3-5	2	4	4	—	2	2
7	Number of leaves	160	126	140	54	70	36	6	12	24
	Longest leave (cm)	20	20	22	20	50	48	16	25	32
	Number of tillers	12	10	7	7	7	6	2	3	4
	Cover (cm)	80	60	80	50	50	12	3	5	5
	Flowering period	fl	fl	fl	fl	fl	fl	—	fl	fl
	Number of spikes	3–5	3-5	3–5	2	4	4	—	2	2

Plants placed in the open environment showed the greatest number of leaves with Form A having the maximum and Form B the least. Tillering was observed to reach its maximum in Form A having the largest number viz, 12 and Form C the least viz, 7. However, leaf length was relatively shorter than that found in the Glass House (Table 3). The longest leaf recorded was 24 cm (in the 5th week) compared to 48 cm found in the Glass House.

The general observation was that stems were thicker and internodes were mostly short, 10 cm compared to 18 cm encountered in the field. This observation agrees with Daubenmire

(1947) who reported that thicker leaf blades, thick stems, short stems and generally smaller leaves are probably due to sunshine which provides more light. Another feature of interest, in the open environment, was the tendency to form mats noted in Form A while Form B showed the prosptrate growth and rooting at the nodes. Form C grew upright. These are the features which collaborate with field observations.

Glass House plants revealed features which are more or less in between the other two environments.

In all the three environments Form C flowered first followed by Form B and lastly Form A. Form C flowered in the 3rd week in Orchid House while Form A did not flower at all here. Flowering in all the three forms occurred for the first time in the sixth week under Glass House and open environment. It appears that the humidity and shade of Orchid House stimulated flowering in Form C and later in Form B.

Other growth responses. Decrease of relative water content over a period of 7 weeks was almost the same for each of the three forms, (Fig. 2). This might be explained by the fact that the dry season was approaching during the period when the experiment was conducted.

The results of leaf weight ratio and leaf area ratio are shown in Table 4. There is not much difference between the three forms. However, it is to be noted that these two parameters together with biomass held us to understand growth rate.

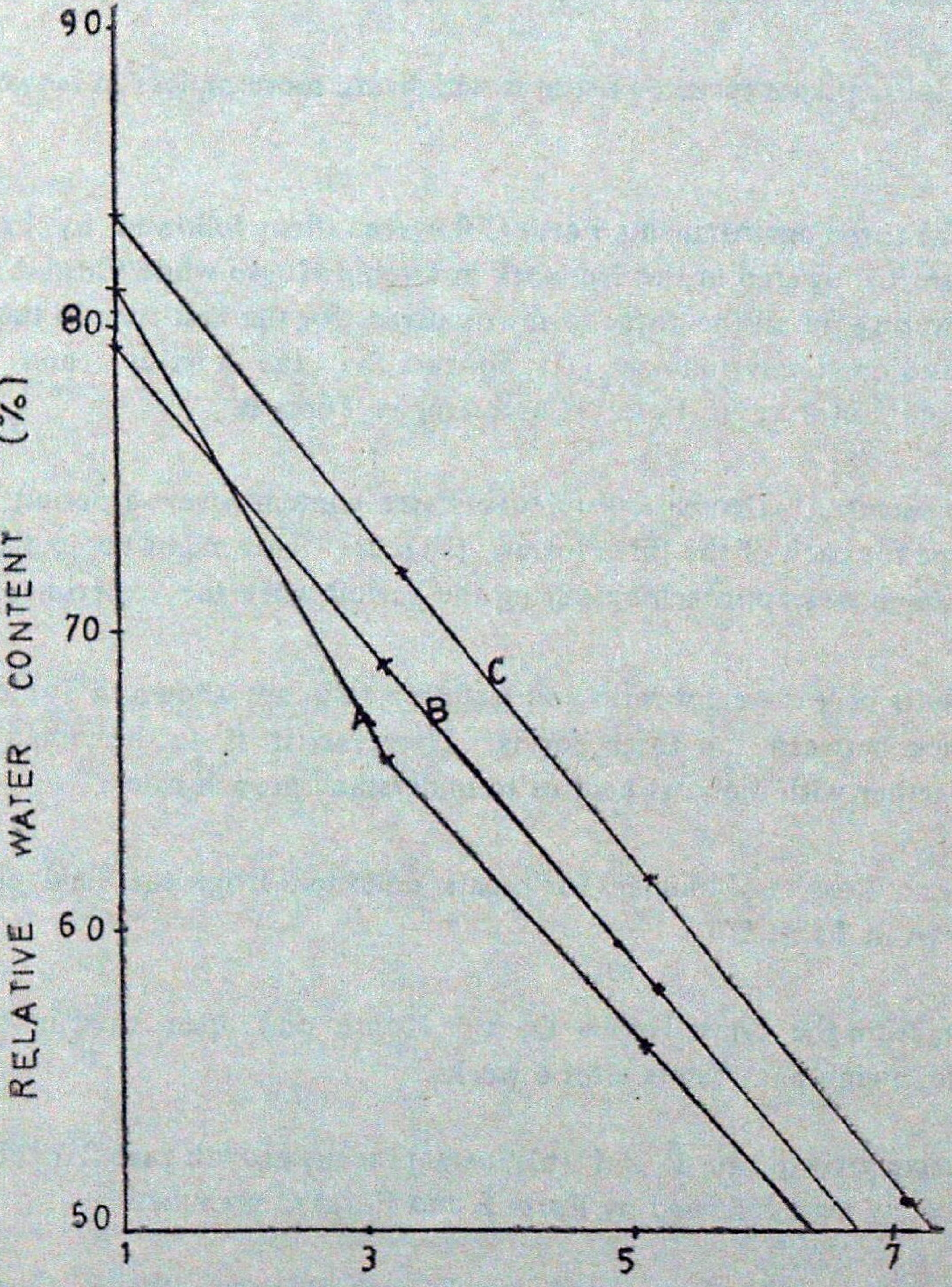
Biomass Studies. Results of biomass for plants collected from the field and the associated plants are shown in Table 5.

Biomass from the Glass House Orchid House and open environment was used to calculate the following parameters after 6 weeks :

(a) Mean relative growth rate $\overline{R}$ and (b) Instantaneous growth rate R (Table 6). In all the cases Form A grew least followed by Form B and Form C grew best.

Growth pattern (Fig. 3) was calculated after Rorison (1969). The results seem to show that Form C grows the fastest and Form A the least. However, the growth pattern curves show that by the 7th week, their growth seems to be more or less the same.

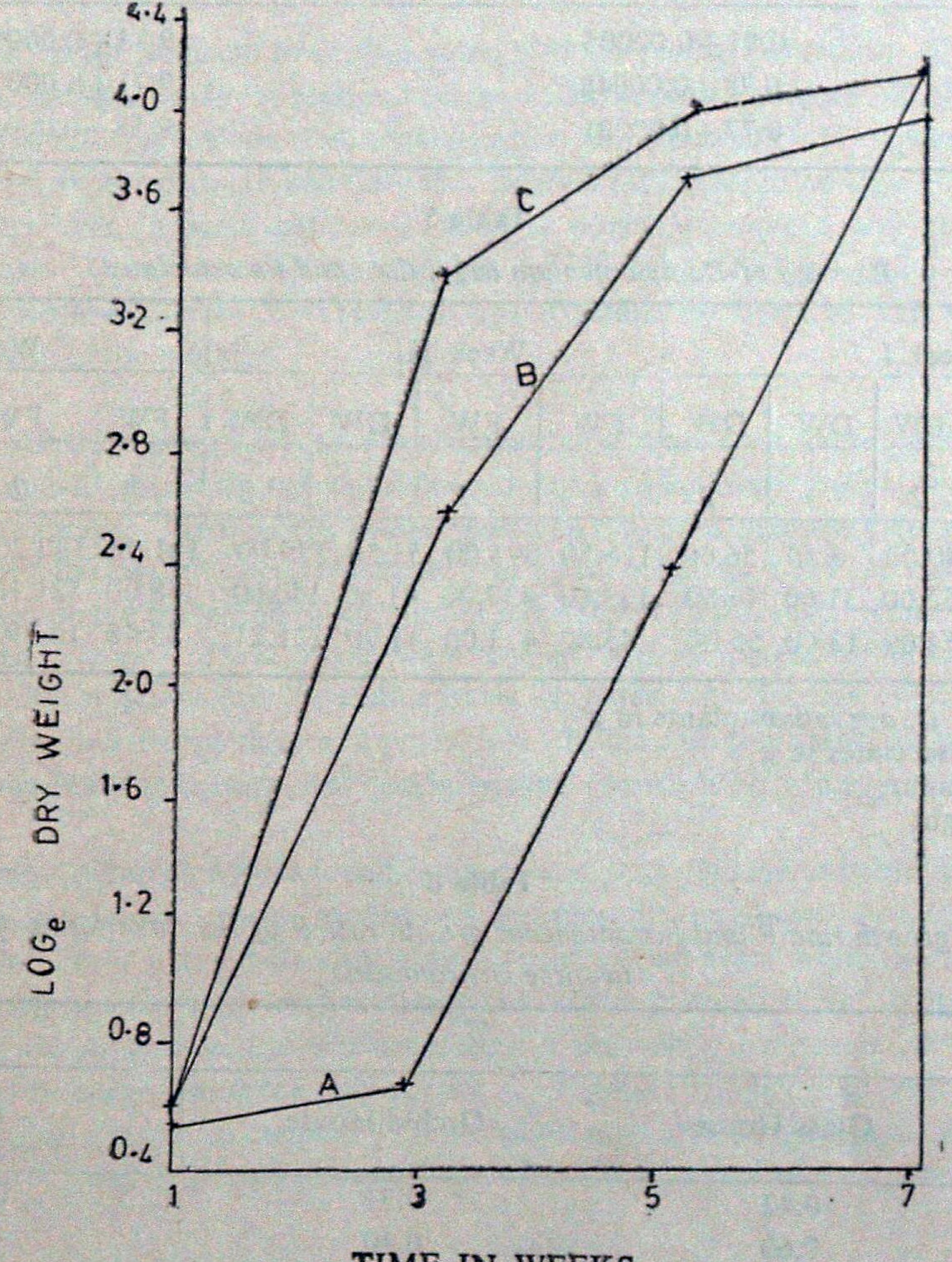
Fig. 2



TIME IN WEEKS

Decrease in water content as the dry season was approaching.

Fig. 3



Growth patterns of the three forms.

Table 4

Leaf weight ratio (LWR) and leaf area ratio (LAR) of Dactyloctenium aegyptium (December, 1978)—Standard deviation.

Forms	LWR	LAR
A	0.81±0.00005	19.83±0.0005
B	0.78±0.00048	19.71±0.00001
C	0.77±0.00001	19.58±0.0005

Table 5

Biomass of Dactyloctenium aegyptium and its associates

Form	Week I				Week III				Week V			
	FW*	FW	DW	DW	FW	FW	DW	DW	FW	FW	DW	DW
	1*	2	1	2	1	2	1	2	1	2	1	2
A	25.00	240.00	6.50	56.00	116.50	394.00	53.50	179.00	121.00	130.20	33.94	36.46
B	110.00	362.00	31.60	46.60	133.00	437.00	41.50	140.00	158.00	121.16	45.00	33.92
C	48.50	154.00	13.00	55.00	43.80	472.00	11.70	121.21	33.48	169.92	9.99	30.12

1*=Weight of *D. aegyptium* plants in g
2=Weight of associates in g
FW=Fresh weight
DW=Dry weight

Table 6

Mean Relative growth rate $\overline{R}$ and Instantaneous growth rate R of the three forms of D. aegyptium in three environments.

Form	Glass House	Orchid House	Open Environment
		$\overline{R}$	
A	0.42	0.31	0.67
B	0.60	0.40	0.68
C	0.62	0.45	0.71
		R	
A	0.14	0.12	0.14
B	0.16	0.14	0.16
C	0.17	0.15	0.19

Cytological Studies. Cytological studies revealed the differences in chromosome numbers of the three forms and were as follows :

Form A—2n =24
Form B—2n =34 and 36
Form C—2n =38

This might augment to explain some of the different behaviours of the three forms. Darlington and Janaki (1945) reported the basic chromosome number of *D. aegyptium* to be n=10 and n=12. Avdulvov cited by Darlington and Janaki (1945) reported 2n=48, while Gould (1966) reported n=10 and 2n=36. Bogdan (1977) reported 2n=20, 40, 34, 36 and 48. He, however, suggests that 2n=20 and 40 might be diploid and tetraploid forms of *D. aegyptium.* Olorode (1974) reported that 2n=38 and in all probability might have used Form C. However, 2n = 24 as revealed by our studies for Form A has not been reported earlier by any of the workers.

In nature, a species is typically composed of a mosaic of populations, each of which differs genetically, based on the physiological (and sometimes) morphological features; and designated ecotypes. Individuals possess gene-combinations that are more or less attuned to the local peculiarities of the environment. In Sweden Turesson (1922) assembled collections of individual plants belonging to the species but native to different habitats within the species geographical range. These plant were studies and persistent differences were revealed indicating that a taxonomic linnean species is made up of races which exhibit inherent differences in both morphology and pysiology. In his case persistent differences were found in height, earliness to mature, leaf characteristics, growth habit and reproductive habits.

Similar differences were found in the case of *D. aegyptium*, notable among them being growth habit, leaf size, growth pattern and chromosome numbers. Preliminary field studies had revealed Form A to be associated with frequently cut areas while Form B and C were found among equally tall plants indicating differences in competitive ability. However, these differences are not sufficient to warrant a distinct taxonomic distinction. Moreover, as pointed out earlier, *D. aegyptium* is the only species in Nigeria belonging to genus *Dactyloctenium.* The cytological differences coupled with morphological and physiological differences indicate that the three forms observed in nature are infact the ecotypes of the species.

SUMMARY

Field observations about *Dactyloctenium aegyptium* (Linn.) P. Beauv. in the University of Ibadan campus in Nigeria revealed important differences among individual plants. The plants were, therefore, classified into three arbitrary groups designated as forms A, B and C. The three forms were subjected to different cultural treatments to find out if the variations justify their designation as ecotypes. The experiments revealed certain persistent differences among the three forms with respect to :

(a) growth habit, (b) growth pattern, (c) flowering period, and (d) chromosome numbers. The results indicate that the Nigerian representative species of *Dactyloctenium aegyptium* is made up of ecotypes.

नाइजीरिया में डैक्टिलोक्टेनियम इजिप्टियम (लि०) पी० बोव० की संख्या में भिन्नता पड़ने का प्रारम्भिक अध्ययन

लेखक बी०एम० शर्मा व ए०ओ० शिबिंग

सारांश

नाइजीरिया में इबादान विश्वविद्यालय में डैक्टिलोक्टेनियम इजिप्टियम (लि०) पी० बोव० के विषय में किये गये क्षेत्र प्रेक्षणों से अलग-अलग वृक्षों के बीच महत्वपूर्ण अन्तर होने का पता चला है। अत: पादपों को तीन मनोनीत वर्गों में बांटा गया है जिन्हें ए, बी और सी तीन रूपों में रखा गया है। इन तीन वर्गों में भिन्न-भिन्न संवर्धन उपचार यह मालूम करने के लिए कराये गये कि क्या ये अन्तर इन्हें वासप्ररूप निर्धारित करने का औचित्य सिद्ध करते हैं। संपरीक्षणों ने इन तीनों रूपों में निम्न दृष्टियों से सर्वदा वर्तमान रहने वाले अन्तर प्रकट किये हैं (क) बढ़ने का स्वरूप (ख) बढ़ने का रूपसज्जा (ग) पुष्पन का समय और (घ) पित्रगुण सूत्र संख्या। परिणामों से पता चलता है कि डैक्टिलोक्टेनियम इजिप्टियम की प्रतिनिधि नाइजीरियाई जातियां वासप्ररूपों से बनी हुई हैं।

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A NEW SPECIES OF *CLERODENDRUM* LINN. (VERBENACEAE) FROM INDIA

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During a botanical exploration of Subansiri district, Arunachal Pradesh (NEFA) in 1977 the authors collected a highly ornamental species of *Clerodendrum* with scarlet red flowers and coppery red leaves. On comparision with the specimen kept under *Clerodendrum lasiocephalum* in the F.R.I. Herbarium, Dehra Dun this collection matched with only one sheet, viz. Bor s.n., collected from Merangkong (Nagalnad) while rest of the five sheets, belonging to three collections, differed from it.

C. lasiocephalum, described by C.B. Clarke (1885), was originally based on Griffith's collection No. 6055 from Mishmi (Lohit district, Arunachal Pradesh) which is in fruiting stage. Later Fischer (1941) amended the description on the basis of flowering specimens of Clarke No. 38106 (A) from Nungpo (Khasi Hills) and No. 44144 (A) from Shillong, both in Meghalaya; he also cited Booth s.n. and Bor No. 2724, collected from Dupla Hills (Arunachal) and Khonoma (Nagaland) respectively. Recently photographs of all these collections were obtained from the Director, Royal Botanic Gardens, Kew (England). On examination of these photographs it has been found that only Booth's collection maches well with that of Griffith's, while the other collections cited by Fischer do not match with the type. A cri ical study of the majority of specimens so far identified, or rather misidentified as *C. lasiocephalum,* deposited in herbaria at Dehra Dun, Shillong and Howrah show that they belong to a new species which is described below.

Clerodendrum fischeri Naithani et Bennet *sp. now.*

Clerodendrum lasiocephalo Clarke similis tamen differt foliis ovatis, cordatis atque paleo brunneis; calyce in cupolam ad 2/5 longitdunisis ejus unito; corolla alba; filamentis atque stylo ad 4 cm longis.

Types : Khonoma 1500 m, Nagaland, 22.4.1935, *N.L. Bor* 2724 (holotype DD; isotype DD).

Clerodendrum fischeri Naithani & Bennet *sp. nav.*

Similar to *Clerodendrum lasicocephalum* Clarke but differs in having ovate, cordate, pale brown leaves; calyx being united below up to 2/5 its length in the form of a cup; corolla white; filaments and style being up to 4 cm long.

A shrub up to 2 m high. *Leaves* ovate, with rounded or cordate base, 5-16×3-16, cm, pale brown, tomentose on both surfaces, margin irregularely sharply dentate-ciliate, primary nerves 5-8 pairs, petiole 2-11 cm long. *Panicle* sessile or on a shoot peduncle,

up to 5 cm long and 9 cm across; bracts elliptic-lance olate to oblanceolate, tomentose to pubescent; pedicels 4-3 mm long. *Calyx* united below up to 2/5 it length in the form of a cup, glabrous to pubescent or ciliate; tube 7-8 mm long; lobes linear-lanceolate, finely acuminate, margins glabrous or ciliate. *Corolla* white, glabrous or minutely hairy; tube up to 3.5 cm long; lobes 4, ovate, rounded, 1×0.7 cm. *Stamens* 4, long-exserted, filaments filiform, up to 4 cm long; anthers linear, cells divaricate at base and 3-5 mm long. *Ovary* oblong; style filiform, twice the length of corolla-tube bifid. *Drupe* red, 6 mm in diam.

Type : Khonoma 1500 m, Nagaland, 22.4.1935, *N. L. Bor* 2724 (holotype DD; isotype DD).

Specimens examined (those marked with an asterisk seen in the form of photographs only):

India : Nongkhlew, Assam 15.6.1958, *Panigrahi* 16226 (Assam); Khonoma, Nagaland, 22.4.1935, *Bor* 2724 (DD); Naga Hills, April 1886. *Prain* s.n. (CAL); Umron Forest, Khasi & Jaintia Hills, 13.3.1932, *Deka* 9950 (Assam); Govt. Garden, Shillong 23.8.1931, *Sri Ram* 9331 (Assam); Nongoph Forest, Meghalaya, 11.6.1964, *Rao* 38742 (Assam); Balaiba Tilla, Nongpoh, 27.7.1964, *Joseph* 37407 (Assam); Assam, May 1895, *Watt* 11619 (CAL); North Khasi. Hills, 2.4.1894, *Gammie* 292 (CAL); Nongpoh, 10.5.1885, *Clarke* 38106 A (K)*; Shillong, 2.7.1886, *Clarke* 44144 A(K)*.

Burma : Maymyo, September 1931, *Parkinson* 314 (DD); Maymyo, 27.4.1908, *Lace* 3166 (CAL, K*); Mandalay, 23.5.1951, *Pokhant* 2084 (DD).

Distribution : India (Assam, Nagaland and Meghalaya) and Burma.

Etymology : The taxon is dedicated to Dr. C.E.C. Fischer for his valuable contribution to the flora of Assam.

The description furnished by Fischer (1941) actually belongs to a mixture of this new species and the real *C. lasiocephalum*. A detailed description of the latter is, therefore, also provided below.

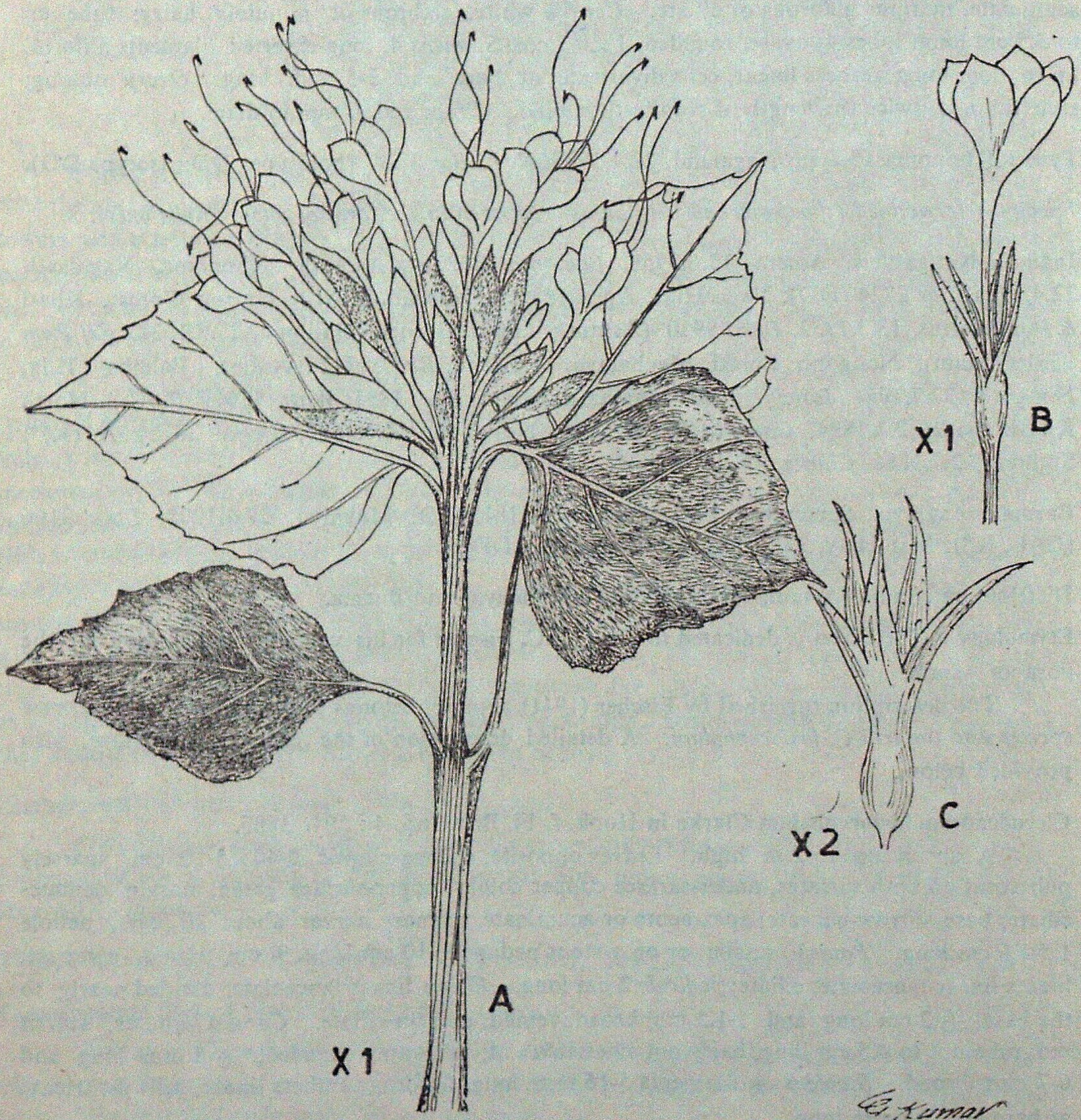
Clerodendrum lasiocephalum Clarke in Hook. f. Fl. Brit. Ind. 4 : 594. 1885.

A shrub up to 2 m high. *Leaves* opposite, oblong-elliptic $9\text{-}40 \times 5\text{-}20$ cm, sparsely pubescent on both surfaces, under-surface copper colour, upper-surface green, margin dentate-ciliate, base narrow-cuneate, apex acute or acuminate, primary nerves about 10 pairs, petiole 1.5-1.6 cm long. *Panicle* sessile or on a stout peduncle, 10 cm long, 9 cm across, compact; bracts linear-lanceolate, ciliate; *pedicels* 2 cm long. *Calyx* linear-lanceolate, divided nearly to the base, $\pm$ 2 cm long and 1-1.5 mm broad, veined, margin ciliate. *Corolla* tubular, scarlet red; tube up to 4.5 cm long, hairy out side; lobes 4, obovate, rounded, $\pm$ 8 mm long and 6-7 mm broad. *Stamens* 4; filaments 5-15 mm long, filiform; anthers linear, cells divaricate at base and 3-5 mm long.

Ovary oblong; style filiform, as long as the corolla-tube; stigma bifid.
Drupe red, 6-7 mm in diam.

Type : Mishmi, *Griffith* 6055 (K).

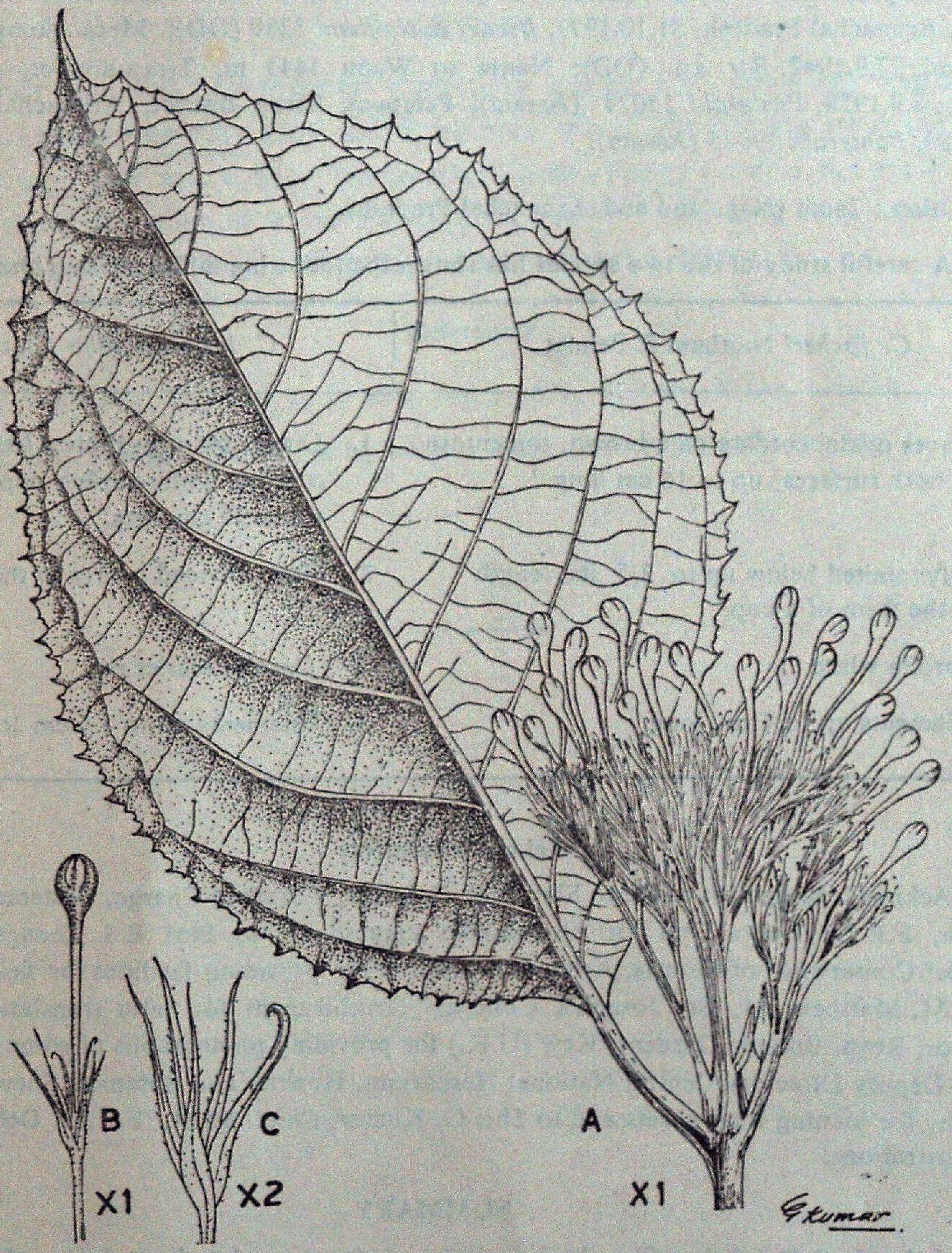
Fig. 1.



Clerodendrum fischeri Naithani and Bennet

A—Flowering twin, B—Flower. C—Calyx.

Fig. 2



Clerodendrum lasiocephalum Clarke

A—Flowering twig. B—Flower. C—Calyx

Specimens examined (those marked with an asterisk seen in the form of photographs only):

India: Dupla, *Booth* s.n. (K)*; Mishmi, *Griffith* 6055 (K)*; below Yazuli 1500 m, Subansiri district, Arunachal Pradesh, 31.10.1977, *Bennet & Naithani* 3280 (DD); Merangkong 1650 m, Nagaland, 27.9.1942, *Bor* s.n. (DD); Nausa to Wanu 1443 m, Tirap district, Arunachal Pradesh, 2.9.1958, *Panigrahi* 15074 (Assam); Petepool, Tirap district, Arunachal Pradesh, 26.9 1959, *Panigrahi* 19065 (Assam).

Distribution : India (Nagaland and Arunachal Pradesh).

A careful study of the two species has shown the following differentiating characters :

C. fischeri Naithani & Bennet	*C. lasiocephalum* Clarke
1. Leaves ovate, cordate pale brown, tomentose on both surfaces, up to 16 cm long.	1. Leaves oblong-elliptic, base narrow-cuneate, under-surface copper colour, up to 35 cm long.
2. Calyx united below up to 2/5 its length in the form of a cup.	2. Calyx divided nearly to the base.
3. Corolla white	3 Corolla scarlet red.
4. Filaments up to 4 cm long.	4. Filaments up to 1.5 cm long.

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SUMMARY

It has been found that *Clerodendrum lasiocephalum* sensu lato is a mixture of two distirct species. While *C lasiocephalum* Clarke senu stricto has bigger coppery leaves and scarlet red flowers with shorter filaments, the other species which is new and described in the present paper as *C. fischeri* Naithani & Bennet has smaller leaves and white flowers with larger filaments. The former is found only in N.E. India and the latter in N E. India and Burma.

क्लेरोडेण्ड्रम लि० प्रजाति (भेकपदकुल=वर्बीनेसी) की भारत से मिली एक नई जाति

लेखक एच०बी० नैथाणी व एस०एस०आर० बेनेट

सारांश

देखने में यह आया है कि क्लेरोडेण्ड्रम लेसियाकेफालम वृहत अर्थ में दो स्पष्टतः भिन्न पादप जातियों का मिश्रण है। क्ले० लैसियाकेफालम संकीर्ण अर्थों में बड़ी तांबई पत्तियां और शोण लाल वर्ण के छोटे अंशु वाले फूल होते हैं इसकी दूसरी जाति में जो नई तथा इस अभिपत्र में क्ले० फिशेराई नैथाणी व बेनेट नाम से वर्णित की गई है। पत्तियां छोटी व फूल बड़े अंशुओं वाले श्वेत वर्ण के होते हैं। पहले बताई जाति केवल उत्तर पूर्वी भारत में पाई जाती है तथा बाद में बताई दूसरी जाति उत्तर पूर्वी बर्मा में पाई जाती है।

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STUDIES ON THE NATURE AND PATTERN OF DISTRIBUTION OF TENSION WOOD IN *HEVEA BRASILIENSIS* MUELL. ARG. (RUBBER WOOD)

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Introduction

The rubber tree *(Hevea brasiliensis)* has been raised in large scale plantations in many parts of the country specially South India. Planted mainly for tapping latex for manufacture of rubber, the tree has become an important source of industrial wood. In India, the timber is already finding use for packing cases and compressed wood shuttles (Sharma & Kukreti, 1981). It is also likely to be a potential source as a raw material for making pulp suitable for writing and printing paper (Guha & Negi, 1969) Recently the rubber wood has been tried for manufacture fo match splints. However, as the splints were badly sprung, they were referred to us for anatomical examination. Microscopic examination of these splints revealed presence of tension wood as the probable cause of warping. However, match splints prepared from other consignment remained straight on drying and did not show the presence of any tension wood.

Though observations on the occurrence of tension wood as indicated by a pronounced development of gelatinous fibres and its effect on properties have been recorded on a number of Indian and foreign timber species belonging to different genera and families (Ghosh & Rao, 1958; Hughes, 1965) there is only a solitary record of the presence of tension wood in *Havea brasiliensis* by Panikkar (Panikkar, 1971). His observations were, however, confined to only one year old seedlings and mature twigs and branches of this species.

Therefore with a view to studying the occurrence, pattern of distribution of tension wood and extent of gelatinization of fibres in this species, a detailed anatomical examination was carried out on samples of mature tapped wood trees received by the Wood Seasoning Branch of this Institute from Rubber Research Institute, Kottayam, Kerala and the observations are summarised in the present paper.

Material and Methods

The material received comprised of 8 squares (Average dimension : 28cm × 20 cm × 250 cm) from eight trees, about 25–30 years old. The trees were fully tapped and completed their economic period. The logs were collected from basal part of the tree. The squares were further converted mostly into 2 cm thick planks and some scantlings. Most of the material was used for studying seasoning characteristics For anatomical studies, cut ends of only four planks representing 3 different trees were taken up. These were planed with hand planer and examined

as such and after wetting for the occurrence of tension wood both with the naked eye and under the hand lens. For better visibility of tension wood the stains (phloroglucinol in HCl, chlorazol black B and chloro zinc-iodide) were applied on the surface of the samples. Best results were obtained with the application of phloroglucinol in HCl. Even with this stain, the tension wood bands were not very clearly demarcated and it was not possible to quantify the proportion of tension wood microscopically. As such, the entire study was carried out by examining thin sections under the microscope. For this, half portions of cut ends of planks were made into smaller blocks of 1.5 to 2 0 cm and numbered serially for sectioning. From each block a number of sections of 15 to 20/um thick were cut and stained using different combinations of stains such as phloroglucinol in HCl, chlorazol black B, chloro-zinc-iodide, safranin + fast green and Coppick & Fowler stain. Permanent slides were prepared with safranin + fast green combination.

For quantifying the proportion of tension wood three methods namely Randomized Point Counting Method, Planimetry and Intercept methods were tried. Of the three methods, Intercept method was found to be quickest and the best for the purpose. The results were, however, verified by following Planimetry method also.

For SEM (Cambridge S 600) studies, sections of 100/um thick were cut, air-dried, coated with carbon followed by gold palladium DC sputtering. The material was then scanned at a tilt angle of 12°.

Observation

Gross and microscopic examination of wood samples—An examination of planed surface of the wood samples as such and after wetting did not show any distinct demarcation between tension wood and normal wood zones both with the naked eye or under a hand lens. However, an application of phloroglucinol in HCl on the planed surface revealed to some extent the contrast between the two—the tension wood areas with light fleshy colour in contrast to the pink colour of the normal wood.

Under the microscope, the tension wood was easily recognisable as narrow or broad bands of gelatinous fibres extending to several millimetres and also as scattered or diffuse type. Although, tension wood was confined mostly to the early wood, it also occurred in latewood. In the tension wood, the S_3 layer of the fibre wall was gelatinized which appeard as translucent and swollen. It was mostly seen in the from of a convoluted ring However, in the advanced stages it was seen flattening up sometimes even obliterating the lumen completely. SEM studies also revealed that S_3 (G) as gelatinous layer having got separated from the rest of the wall layers. The gelatinous layer which looked homogeneous in its structure when stained with chloro-zinc-iodide, was infact a multilamellated structure as revealed by phloroglucinol in HCl and Coppick & Fowler's stain. Besides, in a few sections, the fibres showed lack of typical gelatinization but when stained with safranin+fast green, phloroglucinol in HCl and Coppick & Fowlers' stains, showed green colour, took no colour with the other stains respectively indicating lack of lignification in S_3 layer i e. incipient stage of gelatinization.

Variation in the proportion of tension wood in the samples studied An attempt was made to quantify the porportion of tension wood in four plank sections representing three trees. Out of the four planks, in two planks representing two trees variation in the proportion of tension wood along the length of 2.3 m long planks were also studied. The results are given below :

Log/tree No.	Planks No.	Incidence of tension wood (%)		
		Minimum	Maximum	Average
1	6 (upper side)	35	54	38
	7 (upper side)	1	38	17
3	2 (upper side)	6	32	15
	2 (lower side)	32	47	18
4	7 (upper side)	43	52	48
	7 (lower side)	63	75	68

Discussion

Hevea brasiliensis which belongs to the Euphorbiaceae is no exception in possessing tension wood as many genera of the family have been found to show the presence of tension wood (Bamber, 1974). Though the presence of tension wood is recognisable in the gross without the application of any stain in a number of timber species (Clarke, 1937; Ghosh & Rao, 1958; Hughes, 1965; Ollinmaa, 1956), in rubber wood, only the application of phloroglucinol in HCl on the cleaned wood surface has been found to be useful in differentiating it to some extent from the normal wood. It may, however, be mentioned that this differentiation was not as distinct as obtained in *Fagus sylvatica* using the same stain (Clarke, 1937). The occurrence of tension wood both in early and late wood in *Hevea brasilinesis* is in conformity with the observations made on *Eucalyptus* (Wardrop, 1964) and on *Bischofia javanica, Canarium* spp. and *Quercus* spp. (Ghosh & Rao, 1958). However, unlike *Eucalyptus* where S_2 layer in the early wood and S_3 layer in late wood that is gelatinised (Wardrop, 1964; Wardrop & Dadswell, 1955), in *Hevea brasiliensis* it is the S_3 layer which is gelatinised throughout.

This observation is further confirmed both by SEM studies and by staining reactio s of the tension wood fibres Staining the sections with safranin + fast green, phloroglucinol HCl, chloro-zinc-iodide and Coppick & Fowler stain, the G layer showed green, no colour, dark brown and no colour. whereas S_1 and S_2 layers showed red, pinkish, brownish-yellow and yellow colours respectively indicating clearly that it is the S_1 and S_2 layers only which are lignified and the S_3 as non-lignified and gelatinised. These stains have further revealed different stages of gelatinisation in this species.

As regards studying variation in proportion of tension wood in rubber wood, though the material was not obtained with this objective, the available data indicate that it varies

Plate
(Fig. 1 to 4)

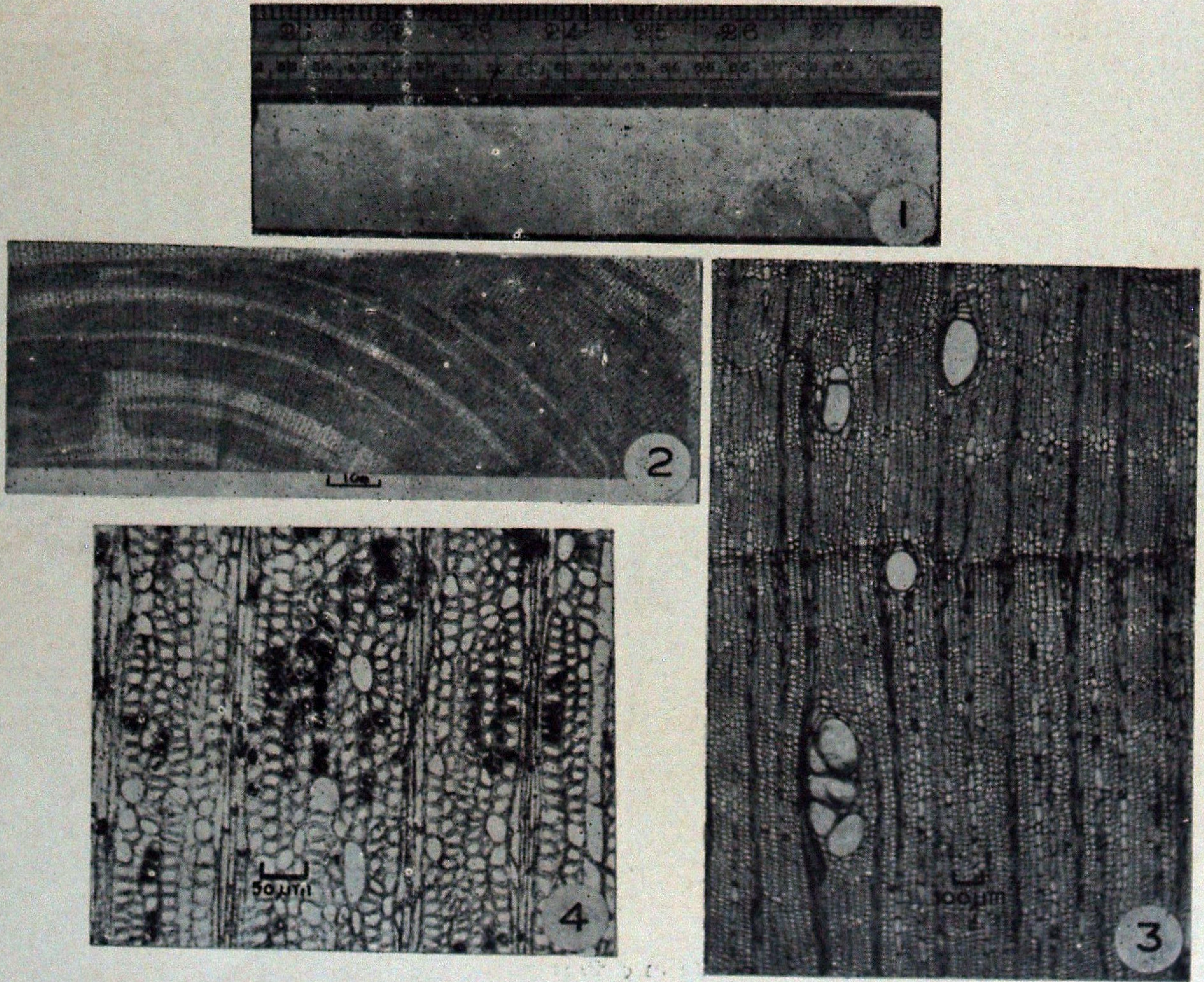
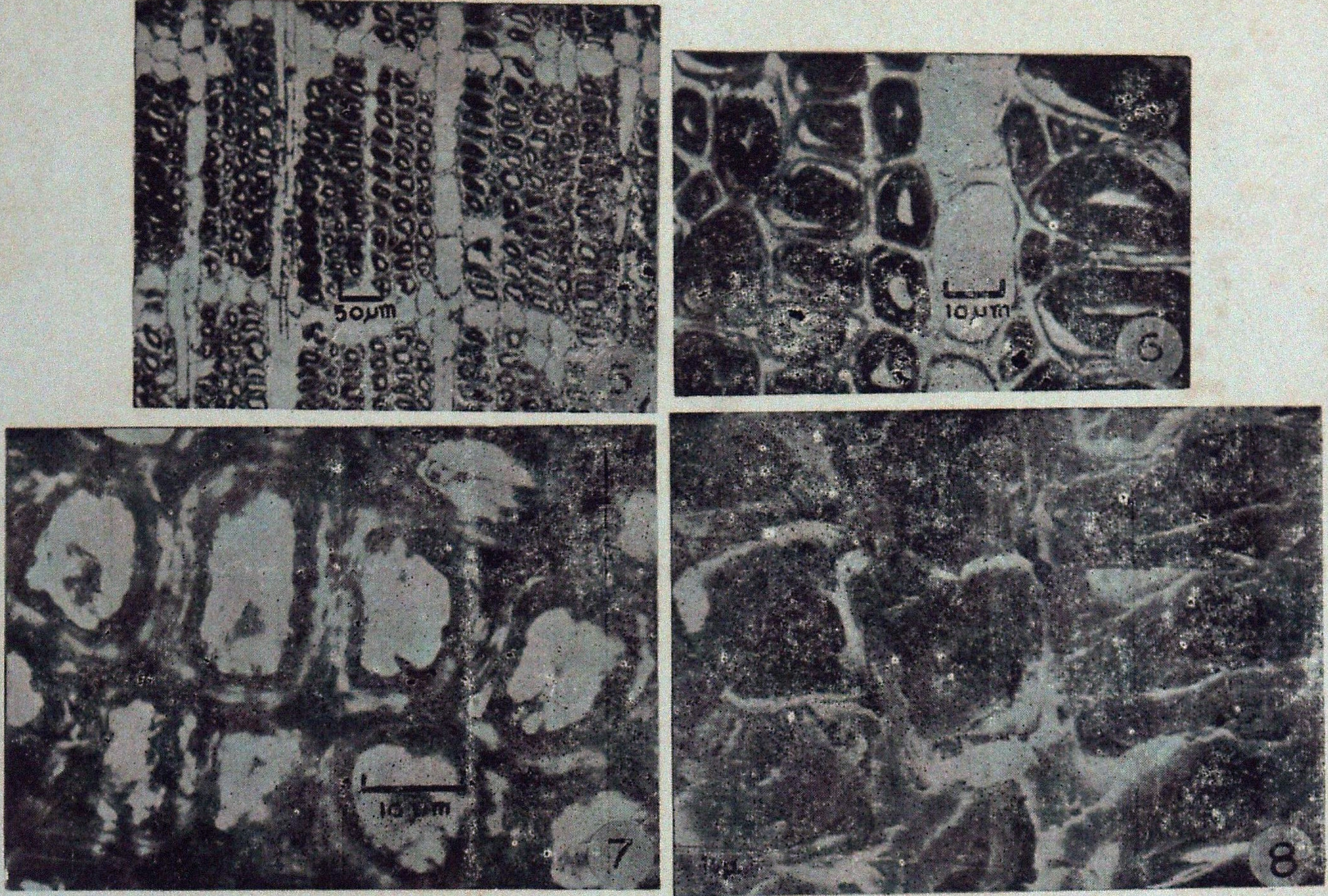


Plate
(Fig. 5 to 8)



widely within and between planks representing different trees. Such a variation in proportion has also been observed in other species (Perem, 1964; Sharma & Kukreti, 1981; Wahlgren, 1957).

Thus the formation of tension wood which has been found to develop right from the seedling stage (Panikkar, 1971) and spreading in wide proportion in mature trees is responsible for affecting the properties of this timber species. The warping of match splints made from some consignments and its absence in other may be attributed to the wide variation in the occurrence of tension wood. As such, the wood is likely to behave erratically depending upon the extent of development of tension wood in this species. Observations on unsuitability of very fast grown *Pterocymbium tinctorium* from plantations in Andamans for match wood veneers due to the presence of tension wood (Ghosh & Rao, 1958) are in conformity with the present investigation.

Explanation of Plate

1. Planed end surface of rubber wood.
2. Sketch showing distribution and pattern of tension wood bands in the half portion of the plank section. Drawn from a series of sections placed end to end and photographed after enlarging the sections.
3. T S. showing tension wood bands both in early and latewood. Sections stained with Safranin + fast green.
4. T.S. showing tension wood (diffuse type). Sections stained with chloro-zinc-iodide.
5. T.S. showing tension wood in bands. Sections stained with chloro-zinc-iodide.
6. T.S. showing swollen gelatinised S_3 layer Sections stained with chlorazol black B.
7. T S. showing non-stained multilamellated S_3 (G) layer. Sections stained with Coppick and Fowler's stain.
8. SEM photograph of T.S. showing gelatinous layer as distinct, thick walled separated from the other wall layers.

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SUMMARY

The nature and pattern of distribution of tension wood in rubber wood (*Hevea brasiliensis* Muell Arg.) has been studied. The studies indicate that tension wood in this species can best be recognized under the microscope only. It has been found to occur both as diffuse and in bands Staining reactions indicate that it is the S_3 (G) layer which is gelatinised and non-lignified. Further, the proportion of tension wood has been found to vary in different planks representing different trees and also along the length within the planks. This erratic distribution of tension wood may be responsible for causing warping of the match splints

हीविया ब्राजीलियेंसिस म्यूल० व आर्ग रबर काष्ठ में आतनन काष्ठ की प्रकृति और उसकी
वितरण सज्जा विषयक अध्ययन

लेखक आर० विजेन्द्र राव, आर० दयाल व बाबूलाल शर्मा

सारांश

इस अभिपत्र में रबर काष्ठ (हीविया ब्राजीलियेंसिस म्यूल० आर्ग) में आतनन काष्ठ की प्रकृति और उसके वितरण की सज्जा का अध्ययन किया गया है। अध्ययन से पता चला है कि इस जाति में आतनन काष्ठ को सबसे अधिक अच्छी तरह से सूक्ष्म दर्शी द्वारा ही पहचाना जा सकता है। यह प्रसृत और पट्टियों दोनों तरह से होता पाया गया है। अभिरंजन प्रतिक्रिया संकेत करती है कि एस$_3$ (जी) स्तर ही जिलेटीन बनता खार विलगुडियित हो जाता है। इसके अतिरिक्त आतनन काष्ठ का समनुपात अलग-अलग वृक्षों के अलग-अलग तख्तों में तथा एक ही तख्ते में लम्बाइयों के साथ-साथ भिन्न-भिन्न होता पाया गया है। आतनन काष्ठ का यह नियमहीन वितरण ही माचिस खपचियों में मरोड़ डालने के लिए उत्तरदायी प्रतीत होता है।

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STUDIES ON THE ACCEPTANCE AND BIOLOGY OF DIFFERENT *TRICHOGRAMMA* SPP. ON THE TEAK SKELETONIZER, *PYRAUSTA MACHAERALIS* WALKER

B V. PATIL* AND T.S. THONTADARYA**

Introduction

The leaves of *Tectona grandis* L.f. (Teak) are heavily damaged by *Pyrausta machaeralis* Wlk. (Syn : *Hapalia machaeralis* Wlk.) (Lepidoptera : Pyralidae). Periodic outbreaks of this skeletonizer are considered to cause considerable loss of increment and quality of teak (Mathur, 1960). Beeson (1941) has estimated the loss to be 13 per cent of the normal current annual increment. Modern tendencies in pest control aim at establishing automatic natural control and biological control is the most satisfactory means of reconciling the aims of forest protection with those of forest management (Mathur, 1977). Extensive survey of the natural enemy complex of this skeletonizer has been carried out in the past which indicated the occurrence of two egg parasites, *T. minutam* Riley and *Trichogrammatoidea nnna* Zehntner (Beeson, 1938). Laboratory studies on the biology of these egg parasites on *P. machaeralis* was completely wanting in the past.

Materials and Methods

The investigations were carried out at the Department of Entomology, College of Agriculture, Dharwad, Karnataka.

Different species of *Trichogramma* that were used during the present investigations were :

Parasite species	Nature of reproduction
Trichogramma confusum sp. (=*australicum* Girault) Taiwan strain)	Biparental
T. evanescens Westwood	,,
T. euproctidis Girault	,,
T. pretiosum Riley	,,
T. semifumatum Perkins	,,
T. maltbyi Nagarkatti and Nagaraja	,,
T. japonicum Ashmead	,,
T. confusum n. sp (=*australicum* Girault) (Mandya strain)	,,
T. brasiliensis Ashmead	Uniparental
T. pkcal hybrid	,,

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Fresh eggs of the teak skeletonizer were exposed to different species of *Trichogramma* for acceptance study. For each mating pair of parasite, 50 eggs glued on the parasite card piece were exposed for 24 hours. The parasitized eggs were held in specimen tubes closed with cotton plug till the emergence of the adults. Number of unparasitized and parasitized eggs were noted and percentage of parasitisation was calculated. Each treatment had five replications.

Biology

Freshly laid eggs of the skeletonizer were used for these experiments. The mating pairs of the biparental parasites, collected from the freshly emerged culture, reared from *Pyrausta* eggs were released at the rate of one pair per specimen tube measuring 7.5 cm×2.5 cm. In case of uniparental parasites only one parasite per specimen tube was released. The month of the speeimen tube was closed with double layered fine cloth and was held in position by rubber band. Each experiment had five replications. Data on the total life-cycle of all the species of *Trichogramma* parasites were recorded.

The effect of *P. machaeralis* eggs on the size of the parasite if any, was studied by taking 20 male and 20 female parasites of each species that had emerged from the eggs of *P. machaeralis* and later compared with the parasite adults that had emerged from the laboratory host, *Corcyra c phalonica* St. They were mounted on Hoyer's media and dried in an oven. Mean length and breadth of the parasites were measured with an occular micrometer after calibrating with stage micrometer.

Generally the eggs of various ages of the host would be available for parasitisation by the parasites under field conditions. Hence, a study was taken to find out on the acceptability of the skeletonizer eggs of different ages by the *Trichogramma* parasites. Every day from 6.00 p.m. to 8.00 p.m. fresh teak leaves were exposed to ovipositing females of *Pyrausta* moths and eggs thus collected were held separately. As a result, on the 2nd day night fresh, one day old, and two days old eggs of ±two hours old were made available. Fifty eggs of each age were exposed to five pairs of different species of *Trichogramma* for a period of two hours. Each treatment had three replications. Number of eggs parasitized were noted down for each species. From this, the percentage of parasitism for each species was calculated.

Results and Discussion

During the present study all the ten *Trichogramma* parasites were found to accept the eggs of *P. machaeralis* and successfully completed their development in them. These findings are further supported with the earlier reports of Beeson (1938 and 1941) and Beeson and Chatterjee (1939) who reported the successful parasitization of *P. machaeralis* eggs by *T. minutum* and *Trichogrammatoidea nana* in South India. During the present investigation out of the ten *Trichogramma* species, *T. brasiliensis*, *T. evanenscens* and *T. pkcal* produced maximum parasitization of 77.60, 73.20 and 76.40 per cent respectively (Table 1). The studies also showed that *T. confusum* (Mandya strain) completed its life-cycle by taking the shortest period of 206.40 hours, whereas *T. euproctidis* has the longest period of 230.40 hours

(Table 2). No earlier reports are available on the life-cycle of *Trichogramma* on the eggs of *P. machaeralis* form comparison.

Table 1

Acceptability of the eggs of Pyrausta machaeralis Wlk. by Trichogramma spp.

Parasite species	Percentage eggs parasitized*	
	Mean**	Range
T. evanescens	76.40	72—82
T. confusum (Taiwan strain)	65.60	64—70
T. confusum (Mandya strain)	66.40	64—72
T. euproctidis	63.20	60 – 68
T. pretiosum	47.60	40 – 58
T. semifumatum	64.80	58—70
T. brasiliensis	77.60	70—82
T. maltbyi	57.20	52—62
T. pkcal (hybrid)	73.20	68—78
T. japonicum	52.00	44—56

* 50 eggs of skeletonizer were exposed.

** Average of five replications.

Table 2

Life-cycle of different Trichogramma parasites on the eggs of Pyrausta machaeralis Wlk. and Corcyra cephalonica Staint.

Parasite species	Life-cycle on *P. machaeralis* (in hours)		Life-cycle on *C. cephalonica* (in hours)	
	Mean	Range	Mean	Range
T. evanescens	211.20	204–216	218.40	216–228
T. brasiliensis	220.80	216–228	228.00	228–228
T. confusum (Mandya strain)	206.40	204–216	216.00	204–228
T. euproctidis	230.40	228–240	230.40	216–240
T. pkcal	223.20	216–228	225.60	216–240
T. semifumatum	216.00	204–228	220.80	204–228
T. maltbyi	225.60	216–228	225.60	216–240
T japonicum	211.20	204–216	218.40	204–228
T. pretiosum	225.60	216–228	228.00	216–240
T. confusum (Taiwan strain)	216.00	204–228	220.80	216–240

All the ten *Trichogramma* parasites preferred fresh eggs of *P. machaeralis* when compared to one day old and two days old eggs for oviposition (Table 3). This variation may be mainly attributed to the embryonic development in two days old egg which showed less preference. Similar observations were made by earlier workers on other insect pests. The adults that emerged from *P. machaeralis* eggs were smaller in size when compared to the adults that emerged from the laboratoy host, *C. cephalonica* (Table 4). This may be related to size of the host egg i.e., *Pyrausta* eggs are smaller in diameter when compared to *Corcyra* eggs. Similar observations were made by earlier workers on other insect pests.

Table 3

Effect of host (Pyrausta machaeralis Wlk.) egg age on the parasitization by different Trichogramma parasites

Parasite species	Age of the host egg		
	Fresh	One day old	Two days old
T. evanescens	32.26*	24.66*	13.26*
T. confusum (Taiwan strain)	26.28	20.12	9.27
T. confusum (Mandya strain)	28.40	24.60	12.43
T. euproctidis	21.10	16.12	5.76
T. pretiosum	25.30	20.62	8.26
T. semifumatum	29.49	22.76	7.95
T. brasiliensis	29.26	22.33	13.22
T. maltbyi	22.28	15.49	9.65
T. pkcal (hybrid)	32.65	21.22	11.28
T. japonicum	21.45	20.40	6.72

* Percentage of parasitization of *Pyrausta* eggs of different age groups.

Table 4

Influence of the hosts (Pyrausta machaeralis Wlk. and Corcyra cephalonica St.) egg size on the size of different Trichogramma parasite species

Parasite species	*Pyrausta machaeralis*				*Corcyra cephalonica*			
	Male		Female		Male		Female	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
T. evanescens	0.560	0.233	0.586	0.242	0.569	0.231	0.598	0.240
T. pretiosum	0.523	0.216	0.564	0.220	0.512	0.223	0.563	0.223
T. semifumatum	0.591	0.268	0.592	0.274	0·592	0.271	0.590	0.277
T. japonicum	0.574	0.249	0.594	0.291	0.582	0.258	0.609	0.299
T confusum (Mandya strain)	0.582	0.261	0.614	0.286	0.593	0.264	0.622	0.294
T confusum (Taiwan strain)	0.578	0.272	0.591	0.274	0.582	0.282	0.584	0.278
T. euproctidis	0.552	0.215	0.537	0.223	0.540	0.221	0 543	0.228
T. maltbyi	0 559	0.236	0.566	0.237	0.563	0.245	0.571	0.239
T. brasiliensis	—	—	0.569	0.238	—	—	0.574	0.243
T. pkcal (hybrid)	—	—	0.532	0.227	—	—	0.521	0.229

*Average of ten observations.

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SUMMARY

All the ten *Trichogramma* parasite species were found to accept and successfully complete their development in the eggs of the teak skeletonizer, *Pyrausta machaeralis* Wlk. (Lepidoptera : pyralidae). Fresh and one days old eggs were found equally acceptable to all the ten *Trichogramma* species, but two days old eggs resulted in low pecentage of parasitization. The adults that emerged from *P. machaeralis* eggs were smaller in size when compared to the adults that emerged from the eggs of the laboratory host, *Corcyra cephalonica* Staint.

सागौन कंकालक कीट पायराउस्टा मैकीरेलिस वाकर० पर ट्रिकोग्रामा प्रजाति की विभिन्न जातियों के स्वीकार और उनका जैविकी का अध्ययन

लेखक बी०वी० पाटिल व टी०एस० थोंटाद्रया

सारांश

ट्रिकोग्राम्मा की दसों परजीवी जातियां सागौन कंकालक पायराउस्टा मैकीरेलिस वाकर० (शल्किपक्षा: (लेपिडोप्टेरा): पायरालिडी) के अंडों को स्वीकार करती तथा उन पर अपना विकास सफलतापूर्वक सम्पन्न करती पाई गई। ताजे और एक दिन के अंडे ट्रिकोग्रामा प्रजाति की दसों जातियों को समान रूप से स्वीकार पाए गए किन्तु दो दिन के अंडों पर परजीविता का प्रतिशत कम रहा। पा० मैकीरेलिस के अंडों से निकले वयस्क कीट प्रयोगशाला में प्रयुक्त पोषी कोरसायरा केफालोनिका स्टेंट के अंडों से निकले हुए वयस्क कीटों की तुलना में आकार में उनसे छोटे रहे।

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FEEDING PRESCRIPTIONS FOR CAPTIVE MANAGEMENT OF THE GHARIAL, *GAVIALIS GANGETICUS* (REPTILIA, CROCODILIA)

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Introduction

Under the Central Crocodile Breeding and Management Project (CCBMP) of the Government of India nine different States are operating various rearing projects for the Indian crocodilians When the CCBMP was started in 1975 with assistance from the F.A.O. and U.N.D.P., no reliable information were available on the food types and feeding requirements of the dfferent Indian crocodilians through different stages in their life history. The only information that were available were from a few zoos which had crocodilians as exhibits along with other zoo animals. Since food and other rearing facilities are the prime growth factors in crocodilians, in the absence of specific attention to these aspects for zoo crocodilians, zoos have always recorded poor growth rates (for eg, see Singh 1978, Choudhury and Bustard *in Press* for the Gharial). But growing these animals fast under the CCBMP is extremely important because whatever be the ultimate purpose, release for conservation or harvest for commercial utilization, a faster growth rate minimises the management expenditure.

During the past years through the research components of the CCBMP good information have been collected on the food and other captive requirements of the Indian crocodilians under which they record fast growth. In the present paper a management prescription with respect to the various aspects of feeding gharial in captivity have been described.

Materials and Methods

The data presented in this paper are derived mainly from my Ph.D. thesis (Singh, 1978) and based on the experience gained through constant guidance of the project at the Gharial Research and Conservation Unit, Tikerpada, Orissa (GRACU). A group of 10 gharial were trained from the age of two and a half months old to accept food directly from my hand to enable me to know their exact food requirement according to their growth. On the basis of this 'hand feeding experiment' and data collected from feeding schedules fixed by me for over 400 other gharial reared at GRACU between 1975 and 1981, the present feeding prescription have been chalked out.

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The paper assumes that the manager starts with 100 gharial hatchlings and rears them in standard rearing pools, which are 2 × 2 × 0.3 m for hatchlings (up to 12 months age), 4 × 4 × 1 m for yearlings (12 to 24 months age) and larger (e.g., 12×12×2.25 m) for older juveniles.

Feeding Prescription

1. *Feeding Groups.* Each rearing pool is suitable for keeping 8–10 gharial. Each pool should be numbered from 1 to 10, and the gharial kept in a pool should be considered as under the same group number as is the number of the pool they are remaining in. For example, gharial housed in pool no. 5 are considered as Group 5.

While beginning with the hatchlings there may be no remarkable size difference among the groups, but after 6–9 months of growth, even under similar husbandry conditions, size differences will be noticed among members of the same and between differenet groups. At this stage the animals are resorted according to their size to rule out any possible harrassment of small juveniles by larger ones. At this stage and later the feeding treatmenent to the various groups may be different.

Creation of different feeding groups is also necessary when a rearing station has representatives from different years of hatching. Although it is expected that gharial hatched in one year will be easily differentiated from those hatched a year later, in actual observation the slow-growing individuals of 1st year hatching may not be different in size, or may even be smaller than a fast-growing individual of the 2nd year. Under such circumstances individuals of equal size, irrespective of their year of hatching, are treated to be under the same feeding-group.

For creating the different feeding groups the manager should consider the body weight of individual gharial. Only in the absence of information on the body weight should he consider the total body length as the basis for creating such groups. For hatchlings and yearlings upto 15 months of age, the groups should not differ by more than 100 gm body weight, or when length is considered, by more than 20 cm. For larger juveniles, up to 27 months old, the difference, should not be more than 500 gm or 30 cm. If older juveniles, differing by more than 3 kg or 30 cm, are kept in the same pool, food requirement of each gharial should be calculated from the body weight (see below) and accordingly adequate food should be provided.

2. *Food types.* Hatchlings in captivity insist on live fish released into their rearing pools. Length and width of fish provided into the pools are important to be considered. A greater width restricts swallowing, while a greater length restricts successful manoeuvre of the fish along the lenght of the snout. Fish with a maximum body length of 40 mm and body width of 10 mm can be provided to hatchlings less than 50 cm long, and for larger hatchlings the length of the fish can be up to 60 mm and the breadth up to 20 mm. Examples of such fish are *Amblypharyngodon mola, Rasbora doniconicus* and fingerlings of *Puntias* and *Labeo* sp. Fish with potentially injurious spines should be avoided.

Large juveniles are capable of handling fish which are slightly oversize. If the length is more the gharial chop off a piece and swallow the rest, and if the width is more the fish is held in its swimming posture and pressed between the jaws to make it soft for easier swallowing. However, gharial of about 1 m length should not be offered fish greater than 80 × 30 mm size, and gharial of about 1.5 m length should not be offered fish of 120 × 40 mm or larger.

3. *Feeding frequency.* In hatchling pools an ideal population of live fish is to be maintained from which the hatchlings feed as and when they need. The manager should aim to maintain a population of 300-400 live fish in each pool. This means, after an initial release of this number of fish the manager will calculate the loss in population that is occurring due to feeding, and replenish the loss. Periodical checks during pool cleaning will further assist in this procedure.

For yearlings and older juveniles up to an age of 3 years, six-days a week feeding is recommended. For older juveniles and sub-adults this schedule is applicable during non-winter months. During the winter, when normal appetite is low in larger gharial, a feeding schedule for 4–5 days a week will be ideal These feeding days should not be continuous, instead well spread over the week. On the feeding days food should be offered at only one time.

4. *Quantity of food.* In Table 1 the quantity of food required for 100 gharial at any particular age between hatching and 5 years of age is given These recommended quantities are for gharial which show a good growth rate, attending approx. 89 cm in 1 year, 142 cm in 2 years, 209 cm in 3 years, 247 cm in 4 years and 278 cm in 5 years. The Table assumes that the winter season is between October and January, and the rain between June and September. The hatching month for gharial has been taken as June.

5. *Record maintenance.* Good husbandry procedures include the keeping of a good record of what are happening at the husbandry unit. One of these records is that on feeding. Appendix 1 provides a proforma which can be used in keeping feeding records.

Feeding records enable the manager to know about the past and also provide a basic guideline for the future. The food requirement given in Table 1 is a guideline under specific conditions, which may not be precisely true to the environmental conditions and other husbandry aspects to which the manager is concerned. Under such circumstances the record helps him to create his own guideline, and also modify the management methods if the results are already not better.

6. *Other considerations*

(a) *Disturbance and feeding.* On the days when pools are cleaned or hatchlings or older juveniles are caught for measurement or transfer, these gharial do not feed at all or normally. Therefore, disturbances should not be too often to become responsible for retarded growth.

Table 1

Food requirement of gharial in captivity from hatching to five years of age.

Age in months	Period	Food for 100 gharial per day (kg)	Yearly total requirement (kg)
1–6	Jun–Nov	1.1	
7–8	Dec–Jan	1.0	
9–11	Feb–Apr	2.2	
12	May	3.6	564.0
13–14	Jun–Jul	4.0	
15–16	Aug-Sep	4.5	
17–18	Oct–Nov	6.0	
19–20	Dec–Jan	4.8	
21–23	Feb–Apr	9.5	
24	May	14.5	2,448.0
25–26	Jun–Jul	14.5	
27–28	Aug–Sep	18.5	
29–30	Oct–Nov	20.0	
31–33	Dec–Feb	17.0	
34–35	Mar–Apr	25.0	
36	May	40.0	7,410.0
37–40	Jun–Sep	40.0	
41–42	Oct–Nov	50.0	
43–44	Dec–Jan	34.0	
45–47	Feb–Apr	66.0	
48	May	75.0	18,030.0
49–52	Jun-Sep	75.0	
53–56	Oct-Jan	46.5	
57–59	Feb–Apr	75.0	
60	May	90.0	24,030.0

(b) *Care of live fish during pool cleaning.* During regular cleaning of hatchling pools where live fish populations are maintained, if care is not taken the fish will die in large numbers. A gharial manager is aware that it is extremely difficult to arrange proper size live fish for a large number of gharial hatchlings. Therefore, precautions must be observed at every step to reduce live fish loss. One method which I have found working good is as follows:

(i) Before a pool is drained out completely, the hatchlings are collected in wide-mouthed tubs. 5–6 hatchlings are kept in a tub of 45 cm high and 45 cm basal diameter. The tubs are kept in shade till the pool cleaning is over.

(ii) The fish are scooped out from the pool and kept in half-filled buckets. Upto 75 fish are kept in a 7-liters bucket. The buckets are covered with netted cloth and kept in shade.

(iii) After cleaning the pool and refilling it by at least 5 cm depth, first the gharial are released, then the fish.

(iv) In each rearing pool a few branches of any water willows like *Salix* sp are kept. These branches prevent fish from jumping out of the water and dying on land Algae growing on these branches provide food to the fish. Also, these branches are liked by the hatchlings to take rest on and bask.

(c) *Purchase and storage of live fish.* The best way to purchase live fish is to standardise their numbers per kg according to the size, because many small fish will die when these are weighed. As an example of this procedure, fish measuring epprox. 3–5 cm in length will number around 300 per kg.

Sometimes a manager may receive more number of live fish required for a day. Such occasions are always welcome and these surplus availability should be stored for the 'lean periods'. It is, therefore, advisable to have two or more 'fish ponds', $1.5 \times 1.5 \times 1$ m size, each with a capacity to hold 700-800 fish of 5 cm size class.

(d) *Food for live fish.* 80% rice powder mixed with 20% dried and powdered termites (collected during the monsoon) have provided a good fish food. Excess use of this food in the rearing pools causes extensive algal growth that lead to problem in cleaning the pool.

(e) *Hygiene.* Young crocodilians are very susceptible to infection Therefore, strict hygiene is to be maintained in the rearing pools. Some of the 'hygiene codes' related to feeding are as in the following:

(i) *Remove dead fish* from the pools every morning and afternoon. Use a plastic container to collect the dead fish. Collect all dead fish from water straight into the container. Do not let water dripping from the fish to fall around the enclosure because this attracts ants. The land areas in the enclosure should be thoroughly searched for dead fish. Sometimes fish jump out from the water and die outside, or even these may escape from the snout of a gharial and fall outside water to die later. Such fish, particularly in the rainy season attract black ants which may kill hatchlings. During the first two years of gharial rearing at GRACU I recorded three hatchling deaths due to ant-attack. The victims are normally debilitated ones. These are first attacked on the eyes and other soft parts of the head.

(ii) Do not feed any gharial with *decaying fish.* These are the sources for enteric infection.

(iii) When a *gharial is detected to be dead in water*, irrespective of the lapse of time between death and detection, it is advised to dispose off all the fish the pool had contained, to clean the pool and *Salix* branches with Potassium permanganate solution (2 gm in 1000 cc water), and sprinkle this solution on the basking areas. Other hatchlings in the pool may be given a bath in 1 : 1000 Potassium permanganate solution.

The manager should remember that it is better to prevent than to cure, and accordingly, look into all possible aspects for maintaining good husbandry.

(f) *Scarcity of whole fish for large juveniles.* The manager may at times experience difficulty in procuring whole fish of suitable size for a large number of gharial between 2 to 5 years of age. Under such circumstances suitably cut pieces, without projecting bones, from large cat fish can be fed. Also prawns can be fed after removing the rostrums.

Appendix I

Proforma for keeping record of feeding gharial in captivity.
(Example for 100 hatchlings, 100 yearlings and 10 3-year old juveniles)

Page 1A (Fish purchase)

Date	No of live fish (rate : no /kg.)				Weight of live fish (kg)	Weight of other fish (kg)	Total weight purchased (kg)
	300	200	150	Total			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.9.81	400	500	150	1050	4.83	1.75	6.58
2.9.81	400	400	150	950	4.33	1.95	6.28
Contd. up to 30.9.81							
Total	9,900	21,000	4,500	35,400	168.0	55.50	223.50

Appendix I (contd)

Page : IB (Fish stores and distribution)

Fish ponds		Hatchling pools			Yearling pools			Large pool	
FP1	FP2	HP1	HP2 up to	HP10	YP1	YP2 up to	YP10	LP1	Remarks
(9)	(10)	(11)	(12)	(20)	(21)	(22)	(30)	(31)	(32)
Stock : 500	500								
3D	2D	1D	6D	1D	1D	—	—	—	HP3 : 1 hatchling didn't show interest to feed.
25	25	35	35	35	90	90	70	1.75	
1D	10D	3D PC (310)	1D PC (302)	1D —	— —	— —	— —	— —	HP3 : hatchling not showing interest to feed (1.9.81) has left eye infected. Treatment followed.
T25	T25	35	+50 35	35	90	90	70	1.95	
Stock : 500	500	990	990	990	2,900	2,700	2,100	55.50	

Note : 1. 'D' against a number indicate the number of dead fish recovered and disposed. 'T' indicates transferred and '+' indicates supplied from stock in fish pond. PC (310) indicates pool cleaned and 310 fish recovered.

Acknowledgements

I acknowledge with thanks the help received from the Orissa Forest Department, Government of India, F.A.O., U.N D.P., and the staff at the Gharial Research and Conservation Unit, in particular Shri I. C. Sahoo and Shri D.K. Sahoo, Research Assistants. Dr. H.R. Bustard, FAO Consultant provided guidance during captive management of the gharial at GRACU.

SUMMARY

Management prescriptions for feeding 100 gharial in captivity from hatching upto 5 years of age are given. The prescription includes considerations of creating feeding groups, choice of food types for different age/size groups, feeding frequencies, food requirements through different ages, record maintenance and other considerations including off-feed due to

disturbances from pool cleaning and handling, care of live fish and arrangement of other food when whole fish are not available for large gharial. The yearly requirement of food for 100 gharial during the first year is 564 kg, second year 2,448 kg, third year 7,410 kg, fourth year 18,030 kg and fifth year 24,030 kg.

घड़ियाल गैवियेलिस गैंजेटिक्स (सरीसृपा : मकरगण) के बन्दी प्रबन्ध में भोजन निर्देशावली

लेखक एल०ए०के० सिंह

सारांश

यहां पर अंडे सेने से लगाकर पांच वर्ष के हो जाने तक के लिये बंदी रखे गये 100 घड़ियालों को भोजन खिलाने की प्रबन्ध निर्देशावली सूचित की गई है। इन निर्देशों में भोजन भूमि निर्मित करने की आवश्यकता, विभिन्न आयु प्रकार वर्गों के लिये भोजन प्ररूपों का चुनाव, भोजन देने की बारंबारता, विभिन्न आयु में भोजन की आवश्यकताएं, अभिलेख का रखरखाव तथा अन्य बातें जिनमें तालाब की सफाई के दौरान विघ्न पड़ने के कारण अन्य भोजन व्यवस्था और उनकी सार संभाल, जिंदा मछलियों की देखभाल तथा जब मछलियां नहीं मिल पाती तो बड़े घड़ियालों के लिए दूसरे भोजन की व्यवस्था सम्मिलित हैं। पहले वर्ष में 100 घड़ियालों के लिए 554 किग्रा०, दूसरे वर्ष 2,448 किग्रा०, तीसरे वर्ष 7.410 किग्रा०, चौथे वर्ष 18,030 किग्रा० और पांचवें वर्ष 24030 किग्रा० भोजन की आवश्यकता रही है।

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BAMBOO WINE FROM *OXYTENANTHERA BRAUNII*

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Introduction

The Tanzanian bamboos belong to the family of *Graminae* and genera of *Bambusaceae.* The common species are *Arundinaria alpina, Oxytenanthera abyssinica, Oxytenanthera braunii, Oxytenanthera macrothyrsus* and *Oreobambos buchwaldii* (Napper, 1965). They are found in large concentrations in the montane ecosystems. Their exact area is not known.

The prevalent uses of bamboo in Tanzania include landscapping, as windbreaks, soil erosion prevention, fodder from green leaves, making basket house and silo construction, spoons, grain sifters, tool handles, ladders, fuelwood and others. Special mention is the use of *Arundinaria alpina* as bamboo water pipes for supplying tapped water to rural population. About 70,000 people are currently being supplied with water under this scheme of total length of 260 km (Lipangile, 1981). Last but not least is the tapping of bamboo wine from *Oxytenanthera braunii*, which is the theme of this paper.

Growth, propagation and maintenance

Oxytenanthera braunii grows best in well drained sandy loam soils. Rainfall is one of the limiting environmental factor. The bamboos growing along the creeks retain their green leaves all the year round and continue producing shoots.

Oxytenanthera braunii forms clumps which increase in size every rain season through creeping rhizomes or rootstocks from which shoots or culms sprout vertically. The tip of the rhizome is sharp and hard. This enables to force its way through the solid soil. The creeping tip eventually turns upwards breaking through the soil to become a culm. At the beginning, the new culms grow very quickly into the air while remaining unbranched. The branching starts in the second rain season at the nodes. In the third year a culm starts producing young culms.

This bamboo species being a 'running type' is propagated by detaching two year old rhizomes together with their culms at their necks, that is the point where they are attached to the parent rhizomes. This is done within the first month of the rain season. The espacement is done in such way that clumps would not join together into one as they expand. The planted culms start producing rhizomes in the second year while wine tapping begins in the third year. The rotation of the clumps is indefinite.

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Since the rhizomes can develop into culms readily in loose and well aerated soil, annual hoeing of the clump soil during the dry season is a necessary bamboo management practice. Negligence of this practice leads to rhizomes development stagnation which implies less bamboo wine production for there will be less culms to be tapped. To avoid the intra-clump congestion, thinning is practised. All stems are access pruned to man's height to facilitate easy movement during the tapping exercise. The inter clump area is usually cultivated for the production of agricultural crops like potatoes, pyrethrum, wheat, maize and others.

The tapping of bamboo wine

When the young culms have reached a height of a metre, their tips are chopped off by a sharp knife in a slanting direction for guiding the flowing direction of the oozing sap. The culms start producing wine on the fourth day and continues for a month. The production per culm increases gradually, reaches maximum and then decreases and eventually ceases. Bigger diameter culms produce more wine per day than thinner ones. An artistically made container locally known as 'mbeta' in Iringa Region (the main tapping area) is tied up to every culm that is being tapped for the callection of the oozing sap. 'Mbeta' is made from a bamboo species *Oreobambos buchwaldii*.

Each culm being tapped has to be visited at least twice a day for wine collection and keeping the sap oozing by making a thin fresh cut with a sharp knife. The oozing culm tips are covered with bamboo leaves to keep off the contaminating insects like flies and sucking ones like bees as well as reducing sap evaporation. The emptying of the containers full of sap is normally done in the mornings and some tappers do in the afternoons too. The tapper usually has a gourd into which the collected sap is poured. The collected bamboo sap can be drunk immediately or stored for fermentation. No additives are added. The wine can be mixed with other drinks like lager beer. A similar use in Tanzania is from the coconut palm *(Cocos nucifera)* tapped along the coastal belt for its palm wine. The bamboo wine is tapped during the rain season.

The importance of bamboo wine

The bamboo wine is a popular drink with the rural population and low urban income earners of Iringa Region. In the villages where bamboo wine tapping is practised, almost every household practises this.

The bamboo wine produced by a household is partly consumed by it, partly used in co-operative farming and partly sold. In co-operative farming, a family requests relatives, friends and neighbours to come to its farm to be helped in a specified field operation like weeding. On such an occassion, the family provides some food and alcohol to the participants. During the bamboo wine season, it is the only drink provided. This co-operation in farming has a cementing effect among friends, relatives, neighbours and families.

The average revenue obtained by a family in one village in 1981 rain season was T. Shs 3400 (£1 = T. Shs 16.4)) for selling 1300 litres of bamboo wine (Swai, 1981). Due to lack

of markets during the peak period of bamboo wine production, the producers are forced to discard part of their wine. It is a source of income to village governments too through the collection of levies paid daily by all people selling the wine at the village clubs.

Many locally brewed drinks in Iringa Region are cereal based using maize, sorghum, and finger millets. The availability of bamboo wine saves some of cereals particularly maize that would have been used in alcohol brewing.

Concluding remarks

The possibilities of canning of bottling the wine should be studied followed by market promotion throughout the country.

SUMMARY

***Oxyteranthera braunii* is a bamboo species belonging to the genera of *Bambusaceae*. It is cultivated in some highland areas of Tanzania mainly for the bamboo wine production during the rain season. The wine is very popular with rural population and low urban income earners. It is a source of income to both families and village governments. Moreover, it is used as a refreshment to participants in co-operative farming More important, the availability of bamboo wine saves some cereals that would have been used in local alcohol brewing for food. The species is propagated by planting the detached two year old rhizome including its culm within the first month of the rain season.**

आक्सिटेनेन्थेरा ब्राउनिआई से बांस मदिरा

लेखक ए०एस०एम० एम्गेनी

सारांश

आक्सिटेनेन्थेरा ब्राउनिआई बम्बूसेसी प्रजाति का बांस है। इसे तन्जानिया के कतिपय पठारी भागों में मुख्यत: वर्षा ऋतु में बांस मदिरा बनाने के लिए लगाया जाता है। ग्राम वासियों तथा नगरों के कम आमदनी वाले लोगों में यह मदिरा बहुत लोकप्रिय है। परिवारों और ग्राम पंचायतों दोनों के लिये यह आय का साधन है। इसके अतिरिक्त यह सहकारी खेती में भाग लेने वालों को नाश्ता-पानी देने में भी उपयोग की जाती है। और इससे महत्वपूर्ण यह बांस मदिरा उपलब्ध होने से वे अनाज बच जाते हैं जिन्हें भोजनार्थ स्थानीय शराब खींचने के लिए उपयोग में लाया जाता है। इस जाति को संधिस्तम्भ युक्त दो वर्षीय शिफास्तम्भ (प्रकन्द) को पृथक करके वर्षा ऋतु के पहले महीने में रोप देने पर प्रवर्धित किया जाता है।

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SOLAR DRYING OF VENEER AND MINOR FOREST PRODUCE

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Introduction

Drying applications for forest products such as timber, veneers, pulp sheets, wood wool, seeds, leaf etc. require air at temperatures varying within a wide range from about 45°C to 140°C.

Timber. Drying of timber sections is largely a diffusion-controlled phenomenon, involving the considerable resistance of the capillary structure of wood to the passage of moisture. Drying times are also prolonged due to the necessity of humidity control for avoiding cracking and splitting, and permissible temperatures (specially for hardwoods) have to be limited to 40°C to 75°C for control of collapse and warping. Thermal efficiencies are therefore low (Kollmann, *et al.*, 1975), steam consumption varying from 1.66 to 4 kg per kg water evaporated in steam heated kilns and electrical consumption from 2 to 4 KWH per kg of water in electrically heated kilns depending upon species, thickness and design of kiln. Solar heated kilns based on the glasshouse principle have therefore been found atractive for timber drying (Sharma, *et al.*, 1980).

Veneers & sheet materials. Drying of veneers, sheet materials and wood wool is accomplished more efficiently at high temperatures above the B.P. of water. This is feasible as the internal resistance to moisture diffusion is considerably less due to the reduced thickness. There is also loosening of the wood structure in peeling or slicing. Drying of thin veneer is significantly controlled by the rate of heat transfer to its surface. For large scale convective drying of veneers, modern jet impingement mechanical dryers are used. The specific steam consumption in steam heated veneer dryers varies from 1.75 to 2 kg per kg water evaporated (Kollmann, *et al.*, 1975).

Several small scale factories in India manufacturing tea-chest plywood, flush doors, textile loom shuttles and picker arms use steam heated or wood waste fired furnace heated tunnel dryers for progressive drying of veneers at lower temperatures upto 70°C. Small factories producing tea-chest plywood, sewing machine covers etc. and needing veneer in small size however generally adopt air drying by spreading the sheets over ground in the direct sun, as mechanical and even tunnel dryers are quite expensive to instal. Sun drying in the open entails poor drying quality, losses through sap stain and decay, besides large yard space requirement.

Hand-made paper is generally manufactured on a cottage scale. The pulp sheets are mostly dried in the open sun like tea-chest veneers, with appreciable losses and degrade.

Minor forest produce. Drying of minor forest produce like seeds that yield edible or non-edible oils, medicinal herbs, and tendu leaf for bidis has to be carried out at forest sites. Open sun drying is almost exclusively adopted at present, taking a week to 10 days Harvesting and drying, particularly of seeds and tendu leaf, has to be completed in the brief span of only about 1½ months immediately preceding the monsoon. Often, because of unexpectedly early rains and long time taken in open sun drying, as much as 25% of the harvested crop of tendu leaf under open sun drying gets spoiled. Wet tendu leaf stored in bundles suffers total waste through discolouration. Sal seed stored wet yields edible fat of increased acidity, necessitating increased refining costs. Temperatures tolerated differ for different kinds of minor forest produce, and are generally within 80°C.

Solar heated air may offer a low-cost alternative for accelerated and controlled drying of these products in cottage or small scale factories or at forest sites. It may also have possibilities for supplemental solar heating of installed progressive tunnel dryers in order to conserve conventional fossil and organic fuels.

Objectives

A "matrix" or packed-bed type solar air heater of simple design is described. Overall solar energy collection efficiency of a system of a four such heaters connected in series has been determined at different delivery air temperatures upto 105°C at two different mass flow rates of air. Drying trials have been made on veneers, sal seed and dhak leaf, using solar heated air from this system.

The objective has been to develop basic solar air heaters design and performance data as well as drying data that could be useful for ultimate design of cottage scale solar driers for veneer, sheet materials, wood wool and minor forest produce, as also for supplemental solar heating of veneer drying tunnels.

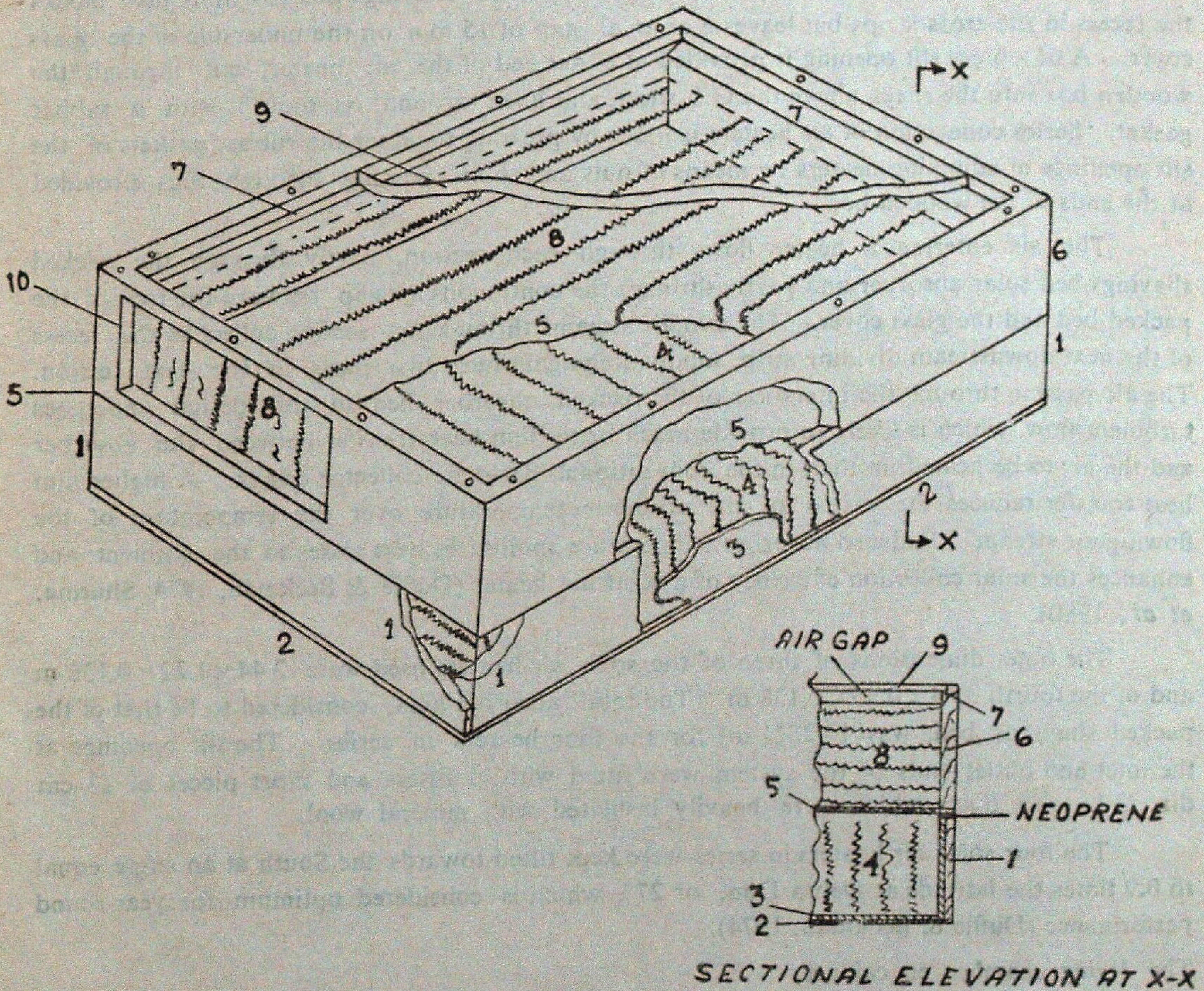
Design of solar air heaters

For applications demanding temperatures between 40°C and 105°C, the "flat-plate" solar collector has been acknowledged to be the most appropriate (Duffie & Beckman, 1974). It can incorporate a large collection area at low fabrication and maintenance costs with simplicity of design. The solar collector used in the present investigation also is, in principle, a flat-plate collector, but with a modified geometry. In this collector, also called the "matrix" collector, the solar absorber consists of a loosely packed bed of blackened lathe shaving scrap from iron machine shops, instead of the conventional blackened flat-plate.

A 2.44 m × 1.22 m 26 gauge G I. sheet, sprayed with dull blackboard paint, together with 9 kg of iron shavings dipped in the same paint and uniformly spread over the G.I. sheet, constitute the solar absorber or collector (see Fig. 1). V—Section neoprene rubber beading is

folded and glued over the edges of the G I sheet all around, and the sheet is then mounted with its edges resting on the top edges of a $2.44 \times 1.22 \times 0.047$ m wooden box The sides of the wooden box are constructed of 25 mm thick timber and the bottom of 9 mm thick marine grade plywood. Before mounting the G I. sheet the interior sides and bottom of the wooden box are first lined with tar felt and over it with a 38 mm thick layer of mineral wood insulation.

Fig. 1



Solar air heaters

1. Wooden box, 2. Plywood, 3. Tarfelt, 4. Mineral wool, 5. G I. Sheet absorber, 6. Wooden moulding, 7. Rebate, 8. Absorber iron shavings, 9. Glass cover, 10. Air inlet.

The neoprene-sheathed edges of the G.I. sheet are finally pressed over the top edge of the wooden box by a screwed on 65×81 mm wood moulding, to make the insulation chamber air and water tight. A single cover of 3 mm thick clear transparent glass is made to rest on a 29 mm wide rebate provided on the interior side of the wood moulding, and sealed around its edges with suitable leak-proof bitumastic or Atul putty.

The space between the G.I. sheet and glass cover is sub-divided into three equal sections in length by installing two 72 mm high vertical wooden strips across the width, which rest on the tray bottom over half of their length and bear a 57 mm high recess from the G.I. sheet surface over their remaining half. The glass cover rests squarely over the top edge of the two wooden cross stips. The height of packed shavings bed (57 mm) just blocks the recess in the cross strips but leaves a clear air gap of 15 mm on the underside of the glass cover. A 61×6 cm slit opening is provided at either end of the air heater, cut through the wooden box into the space above the G.I sheet, and lined around its mouth with a rubber gasket. Series connection of air heaters is made by pressing together the rubber gaskets of the slit openings of adjoining heaters by means of nuts and bolts passing through lugs provided at the ends of the wooden box.

The air entering a heater flows through each section, partly through the packed shavings-bed solar absorber and partly through the continuous air gap between the top of the packed bed and the glass cover. The two air streams through any section collect at the recess of the next downstream dividing strip, subdividing again into two parts in the next section. The air passing through the interstices of the packed absorber bed in this design undergoes turbulent flow, which is likely to provide much better film heat transfer between the absorber and the air to be heated up than in the conventional flat-plate collector design. A higher film heat transfer reduces the excess of the absorber temperature over the temperature of the flowing air stream. Reduced absorber temperature minimizes heat losses to the ambient and enhances the solar collection efficiency of a solar air heater (Duffie & Beckman, 1974; Sharma, *et al*, 1980).

The outer dimensions of three of the solar air heaters used were 2.44×1.22×0.138 m and of the fourth 3.64×0.95×0.138 m. The total absorber area, considered to be that of the packed shavings bed, was 10.2621 m^2 for the four heaters in series. The slit openings at the inlet and outlet ends of the system were fitted with diffusers and short pieces of 13 cm dia. G.I. sheet ducts which were heavily insulated with mineral wool.

The four solar air heaters in series were kept tilted towards the South at an angle equal to 0.9 times the latitude at Dehra Dun, or 27°, which is considered optimum for year-round performance (Duffie & Beckman, 1974).

The drying chamber on cabinet

Veneers & leaf. The dryer used for veneers and dhak leaf was a 1.78 m long × 0.88 m wide × 0.57 m high chamber of plywood construction with a removable side wall. Strips-and-gaps type screens were provided at both the inlet and outlet ends of the chamber, which were fitted with diffusers and short pieces of G.I. duct.

The inlet duct of the system of series heaters was left open to the atmosphere (Fig. 2 a). The insulated outlet duct of the heaters system was connected to the inlet diffuser of the drying chamber, and the outlet duct of the drying chamber was in turn connected to the suction end of a 1 H.P. air blower having a free air delivery of 4100 CFM at 950 R.P.M. The blower discharged directly into the atmosphere.

When the blower was worked, fresh atmospheric air was sucked through the four heaters in series and heated up. The heated air entered the drying chamber through the inlet diffuser and strips-and-gaps type screen, which ensured a uniform distribution of air velocity within the chamber. The spent air was finally exhausted to the atmosphere *via* the outlet duct of the drying chamber and the air blower. The chamber was thus used essentially as a single pass heated forced air drying tunnel. For drying of dhak leaf bundles, removable framed wire gauge racks were fitted inside the chamber.

Sal seed. For the drying of sal seed a vertical drying cabinet 0.61 × 0.61 m in section and 1.22 m high, having four 27 to 33 cm deep sliding removable wooden trays with wire gauge bottoms, was used. The wire gauge bottom was fixed in the bottom tray, but was sliding and separately removable from the upper three trays Thus, the first tray at the hottest bottom end, containing dried seed, can be removed, emptied and replaced when desired. The partially dried seed from the upper second tray can be transferred to the empty bottom tray, and that from the third and fourth trays to the second, just by withdrawing their respective sliding wire gauge bottoms successively Fresh green seed is charged into the top tray at the cold upper end of the drying cabinet. The cabinet dryer is thus used for progressive drying of seed, moved successively from the cold top to the hot bottomtray.

The heated outlet air from the series-connected heaters was admitted at the bottom end of the drying cabinet through a short insulated G.I. duct and a diffuser (Fig 2 b). Hot air percolated upwards through the wire gauge bottoms and seed beds of successive trays in a turbulent flow, drying the seeds en route.

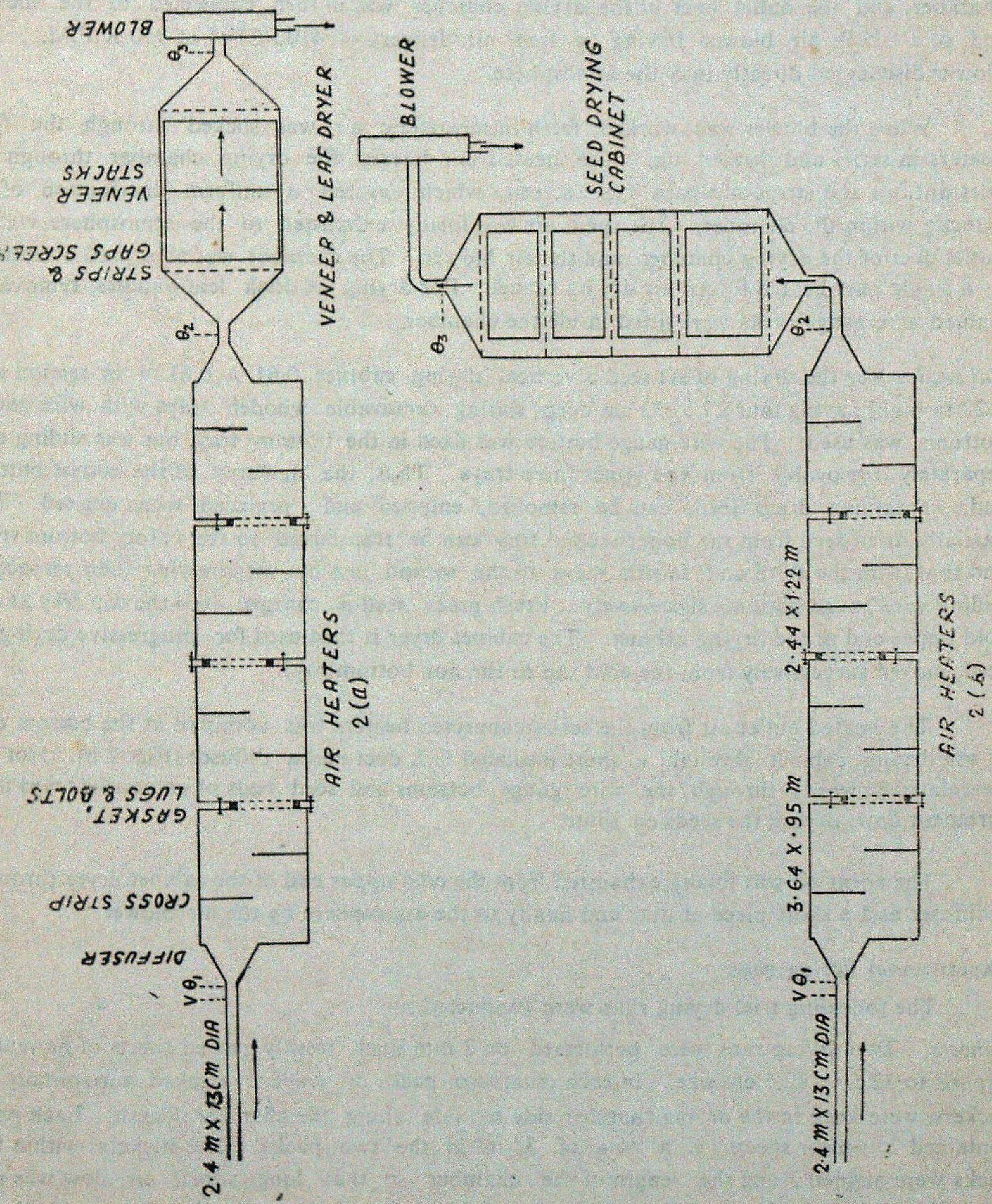
The spent air was finally exhausted from the cold upper end of the cabinet dryer through a diffuser and a short piece of duct and finally to the atmosphere by the air blower.

Experimental drying runs

The following trial drying runs were conducted :

Veneers. Two drying runs were performed on 2 mm thick freshly peeled sheets of fir veneer clipped to 32.5 × 82.5 cm size. In each run, two packs of veneers, stacked horizontally on stickers, were keep in the drying chamber side to side along the chamber length. Each pack contained 2[illegible] veneer sheets i e., a total of 34 m² in the two packs. The stickers within the Packs were aligned along the length of the chamber so that longitudinal air flow was not blocked The packs fitted the complete width and height of the chamber to avoid short-circuiting of flow around the packs.

Fig. 2



Schematic of air heaters and dryer connections.

After initial moisture content tests on some veneer samples by the oven drying method, and determination of the initial weight of the packs (*minus* the weight of the air-dry stickers used), weighing of packs was repeated periodically to determine the kg of water evaporated as well as the current moisture content attained, from the calculated oven-dry weight of the packs *minus* the stickers.

Dhak leaf bundles. For drying of leaf bundles, the drying chamber was fitted with nine removable horizontal racks having plywood bottoms and spaced 50 mm apart from one another along the height of the chamber. Three drying runs were performed with bundles of three different sizes, viz. 50, 25 and 10 leaves to each bundles. The total number of leaves charged was about 9,000 with the 25 and 10 leaf bundles and about 13,500 with the 50 leaf bundles. The bundles on each rack were laid in five parallel rows aligned lengthwise of the chamber. Each row was laid with six 50 leaf, or eight 25 leaf, or twenty 10 leaf boundles. The longitudinal channel between rows of bundles permitted unobstructed flow of hot air from one end of the chamber to the other.

After initial weighing of the trays loaded with green leaf bundles, weighing was repeated periodically to determine the kg of water evaporated.

Sal seed. 7 kg of green seed with wings intact was charged in each of the four trays of the drying cabinet. Trial runs were performed under two different procedures :

(i) Complete solar drying of the whole seed.

(ii) Partial solar drying of the whole seed, followed by de-winging, and final drying of the de-winged seed.

Under the procedure at (ii), green seed was charged simultaneously in the four trays. After seed wings had dried enough in all the trays, the seed was removed for dewinging by manual means. Dewinging was also found possible by spreading the seed in a thin bed on the ground and starting a smouldering fire at one end, which gradually burnt the dried wings in the entire bed.

The dewinged seed was new recharged in the four trays and progressively transferred from the top to the bottom tray for complete drying.

No effort was made in this investigation to use optimum drying temperatures for retaining the seed or leaf quality, and maximum available discharge air temperatures from the solar air heaters were employed in order to assess the drying potential of the equipment.

Observation relating to thermal efficiency of the system

Measurement of solar insolation on the air heaters. Continuous records of total hemispherical solar radiation (beam+diffused) on a horizontal surface, obtained on a pyrheliometer at the F.R.I. Meteorological Station, was made use of for the individual days of experiment. The

rate of insolation H vs. time t record was graphically integrated and averaged over successive known intervals of time for the duration of the drying experiment, thus giving the average rate of insolation $\bar{H}$ received per unit area during successive intervals

The average rate of insolation $\bar{H}_T$ per unit area of the tilted solar air heaters (facing South), during each successive time interval t, was estimated from the corresponding average insolation rate $\bar{H}$ on a horizontal surface, by using the formulae (Duffie & Beckman, 1974).

$$\bar{H}_T = \bar{H} \times \bar{R}_b \tag{1}$$

$$\bar{R}h = \frac{\cos(\phi - S)\cos\delta\cos\omega + \sin(\phi - S)\sin\delta}{\cos\phi\cos\delta\cos\omega + \sin\phi\sin\delta} \tag{2}$$

$$= 23.45 \sin 360 \left(\frac{284 + n}{365}\right) \tag{3}$$

where

S = angle of tilt relative to horizontal, i.e. 30°N

ϕ = latitude at Dehra Dun. i.e., 30°N

δ = angle of declination, i.e, angular position of the sun at solar noon with respect to the plane of the equator

n = the day of the year

ω = hour angle, solar noon being 0°, and each hour being 15° of longitude with mornings positive and afternoons negative

$\bar{R}_h$ = mean angular correction for tilt, reckoned as the mean of R_b values for the hour angles ω_1 & ω_2 at the beginning and end of the particular time interval Δt

The above calculation is strictly valid for the beam component and for diffuse radiation coming from the circum-solar sky. However. since all experiments were invariably made on clear days, the total insolation was treated as though it was all beam radiation, as a close approximation (Duffie & Beckman, 1974)

Temperatures and mass flow rates. The atmospheric air inlet duct to the series solar air heaters was 13 cm in dia. and was kept 2.4 m long, i.e., well in excess of 10 diameters (Spink, 1961), to ensure stabilized flow for measurement of mean duct velocity. Flow velocities were measured in this inlet duct, with the drying chamber or cabinet charged with the material to be dried and connected between the heatersand the blower (Fig 2). A fixed blower R.P.M. was used.

Measurements were made by a standard plot tube and inclined gauge spirit manometer, through a hole in the duct wall. A velocity sean was made along the duct diameter at depth intervals of 6 mm from the duct wall to its centre. A straight line was fitted to the plot of velocity V vs logarithm of distance X from the duct wall, in order to determine the constants A and B in the equation of the well known logarithmic law (Asawa, 1976) relating V and X in ducts :

$$V - A \log X + B \tag{4}$$

The volume flow rate Q through the duct was determined by integration over the duct cross section

$$Q = \int_0^R 2\,(B-X)\quad (A \log X + B)\, dx \qquad (5)$$

where R is the duct radius.

Air temperatures in the system were measured by mercury-in-glass thermometer : (i) in the atmospheric air inlet duct close to the point of entry into the first heater θ_1, (ii) in the short piece of insulated duct at the hot air exit from the fourth heater θ_2, and (iii) in the insulated air duct at the exit from the drying chamber θ_3.

Mass flow rate $\dot{m}$ of air through the system was estimated from

$$\dot{m} = 4, e_1 \qquad (6)$$

where e_1 is density of atmospheric air at inlet temperature θ_1, as seen from tables.

Solar collection efficiency of air heaters. Instantaneous collection efficiency η (Duffie and Beckman, 1974) of the four series heaters during successive known intervals Δt was estimated from :

$$\eta = \frac{(\overline{\dot{m}} \cdot \triangle t) \cdot \overline{c} \cdot \quad (\overline{\theta_2} - \overline{\theta_1})}{\overline{H}_T \cdot \quad A \cdot \quad \triangle t} \times 100 \qquad (7)$$

$$= \frac{(Q \cdot \overline{e_1} \cdot \quad t) \cdot \quad \overline{c} \cdot \quad (\overline{\theta_2} - \overline{\theta_1})}{\overline{H}_T \cdot \quad A \cdot \quad \triangle t} + 100 \qquad (8)$$

where

$\overline{\dot{m}}$ = average mass flow rate during interval $\triangle t$. reckoned from equn. (McMillen & Wangert, 1978) and values of e_1 at beginning and end of interval.

$\overline{e_1}$ = density of atmospheric air at average inlet temperature $\overline{\theta_1}$ prevailing during interval $\triangle t$. as seen from tables.

$\overline{\theta_1}$. $\overline{\theta_2}$ = mean inlet and outlet air temperatures for the series heaters during interval $\triangle t$.

$\overline{c}$ = specific heat of air at the mean system temperature $\frac{\overline{\theta_1} + \overline{\theta_2}}{2}$ as seen from tables.

A = total absorber area.

Thermal efficiency of drying process. The energy usefully employed for drying was evaluated from the total mass of water evaporated from the charge W and the heat of adsorption H_a *plus* the latent heat H_L required per unit mass of water evaporated. Since in case of wood the heat of adsorption is variable with the moisture content range in which drying occurs

(whether above or below the fibre saturation point), an average value for $\overline{H_a + H_L}$ per unit mass of water was determined by integrating the standard $H^1 + H_L$ vs. moisture content curve for wood (McMillen & Wengert, 1978) over the specific moisture content interval in the drying experiment and dividing the integral by the moisture content loss. Thus the useful heat was calculated as $W.\overline{H_a + H_L}$

The drying efficiency was calculated for the entire solar drying system (E) as well as for the dryer alone (E′), as follows

$$E = \frac{W.\overline{H_a + H_L}}{\sum_{o}^{t} A.\left(\overline{H}_T . t\right)} \times 100 \tag{9}$$

$$E' = \frac{W.\overline{H_2 + H_L}}{\sum_{o}^{t} (\overline{\dot{m}} . \Delta t) . \overline{c} . (\overline{\theta}_2 - \overline{\theta}_1)} \times 100 \tag{10}$$

where the denominators in the two cases respectively represent the summations of solar insolation upon the heaters and the heat content in excess of the ambient of the hot air fed to the dryer, over the total drying period t.

Heat absorbed within the dryer from inlet to exhaust air temperature (θ_2 to θ_3) *& Residual heat in the exhaust air at temprature* θ_3 *over ambient temperature* θ_1.

The heat absorbed within dryer was estimated by summation over successive intervals Δt from

$$\sum_{o}^{t} (\overline{\dot{m}} . \Delta t) . \overline{c}' . (\overline{\theta}_2 - \overline{\theta}_3) \tag{11}$$

and the residual heat content in excess of the ambient in the exhaust air from dryer, from

$$\sum_{o}^{t} (\overline{\dot{m}} . \Delta t) . \overline{c}'' . (\overline{\theta}_3 - \overline{\theta}_1) \tag{12}$$

where

$\overline{c}' . \overline{c}''$ = specific heats of air at mean temperatures $\frac{\overline{\theta}_2 + \overline{\theta}_3}{2}$ and $\frac{\overline{\theta}_3 + \overline{\theta}_1}{2}$ respectively prevailing during interval Δt as seen from tables

$\overline{\theta}_1$, $\overline{\theta}_2$, $\overline{\theta}_3$ = mean temperatures during interval Δt for atmospheric air at inlet of heaters, air at outlet of heaters, and exhaust air from dryer, and the summation is for the total drying period t.

Results and Discussion

Collection efficiency of series solar air heaters. The results of performance tests carried out on the series heaters on 26th April and 14th June, 1979 are set out in Tables 1 & 2. Although the blower R.P M was virtually constant, the April test was carried out with the dryer containing stickered stacks of veneers and the June test with the sal seed drying cabinet, connected in series. Because of the higher resistance through the charged seed trays in case of the cabinet dryer, the mass flow rate in the June test was lower, between 2.77 and 2.87 kg/min. than in the April test, between 5.44 and 5.54 kg/min.

Figs. 3 and 4 show the variation in estimated solar insolation rate H_T on the tilted heaters, inlet (or ambient) air temperature θ_1, delivery air temperature θ_2, and the instantaneous solar collection efficiency η (averaged over successive small periods of measurements) for the April and June test days respectively.

The series heaters were able to give delivery air temperatures between 65°C and 89.5°C from 10 to 14 30 hrs in the April test and between 66°C and 105°C from 10.30 to 16 hrs in the June test. The appreciably higher delivery air temperatures in the June test are partly due to heigher solar insolation and partly also due to lower mass flow rates than those in the April test. The delivery air temperatures in both cases are in the range suitable for accelerated drying of veneers, hand-made paper sheets, wood wool and minor forest produce.

The temperature rise $\theta_2-\theta_1$ increased upto a maximum of 51°C in the April test and upto 72°C in the June test. The maximum was generally reached sometime after sloar noon and also sometime after the maximum of solar insolation H_T was first reached. The lag is due to the thermal capacity of the solar air heaters.

The variation in solar collection efficiency with time of day became rather irregular during the period during which solar insolation H_T became irregular due to hazy sky condition, i.e., between 12 and 13.15 hrs in the April test and between 13 and 14.30 hrs in the June test. In general, the estimated efficiency showed an irregular large increase during such periods. This is again atributed to thermal capacity effects (Duffie & Beckman, 1974). As the solar insolation (or the heat input) suddenly decreased due to a hazy sky, the heat output was maintained for some time by the stored heat due to the thermal capacity of the solar air heaters, thus giving a large apparent increase in the estimated collection efficiency.

Considering only the periods in which solar insolation was steadily increasing or decreasing or remained virtually constant, the collection efficiency was between 42.3 and 48.5% in the June test. Overall test averages were 62% and 45.5% respectively. These collection efficiencies are quite high, for the high delivery air temperature rises $\theta_2-\theta_1$ registered. They are better than those observed in some of the experiments done elsewhere with flat plate type collectors (Garg, *et al.*, 1981).

Table

Diurnal variation in solar insolation rate H_T on the solar heaters, the delivery

(A = 10.2621 m² : Mass flow rate $\bar{m}$ with loaded

Time	Insolation rate on horizontal surface H (cal/cm² min)	Angular correction Rb	Insolation rate on tilted heaters HT (cal/cm² min)	Average rate for interval $\bar{H}_T$ (cal/cm² min)	Interval Δt (min)
1	2	3	4	5	6
10.04	0.65	1.0134	0.6587	—	—
				0.6856	15
10.19	0.70	1.0178	0.7125		
				0.7520	15
10.34	0.77	1.0213	0.7915		
				0.8319	30
11.04	0.85	1.0264	0.8724		
				0.9046	26
11.30	0.91	1.0294	0.9368		
				0.9530	15
11.45	0.94	1.0310	0.9691		
				0.9737	30
12.15	0.92	1.0301	0 9477		
				0.9880	30
12.45	0.92	1.0282	0.9459		
				0.9451	15
13.00	0.92	1.0264	0.9442		
				0.9689	15
13.15	0.97	1.0242	0.9935		
				1.0125	15
13.30	1.01	1.0213	1.0315		
				1.0201	30
14.00	0.98	1.0135	0.9932		
				1.0109	15
14.15	1.02	1.0084	1.0286		
				1.0104	15
14.30	0.99	1.0023	0.9923	—	—

Total for the day

Total 10.04 – 13.30 hrs

1

air temp. θ_2, and the instantaneous collection efficiency η on 26 April, 1979

veneer dryer in series = 5.49 kg per min.)

Insolation on heaters during interval $\overline{H}_T$ A. $\triangle t$ (kcal)	Outlet Temp. θ_2 (°C)	Inlet Temp. θ_1 (°C)	Temp. Rise $\theta_2 - \theta_1$ (°C)	Heat gained by Air during the Interval $\overline{m}$. $\overline{c}$ $(\overline{\theta^2} - \overline{\theta_1})$ (kcal)	Collection Efficiency (%)
7	8	9	10	11	12
	65	32	33	—	—
1055.36				756.92	71.7
	73	35	38		
1157.57				805.59	69.6
	74	36	38		
2561.12				1625.70	63.5
	76	37	39		
2413.61				1485.34	61.5
	80.5	38	42.5		
1466.97				897.43	61.2
	81	38	43		
2997.82				1826.08	60.9
	82	38	44		
3041.85				1990.89	65.5
	89.5	38.5	51		
1454 81				1026.70	70.6
	85	38	47		
1491.45				942.11	63.2
	83	39	44		
1558 56				903.55	58.0
	83	39.5	43.5		
3140.60				1836.32	58.5
	84 5	40	44.5		
1556.10				883.39	56.8
	78.5	38.5	40		
1555.33				792.29	50.9
	74	38.5	35.5	—	—
25451.15				15772.31	$\overline{\eta} = 62.0$
19199.12				12260.31	

Table

Diurnal variation in solar insolation rate H_T *on the solar heaters. the delivery air*

(A=10.2621 m^2 : Mass flow rate $\dot{m}$ with

Time	Insolation rate on horizontal surface H (cal/cm² min)	Angular correction R_b	Insolation rate on tilted heaters H_T (cal/cm² min)	Average rate for Interval $\bar{H}_T$ (cal/cm² min)	Interval Δt (min)
1	2	3	4	5	6
10.30	1.10	0.9337	1.0270	—	—
				0.9143	30
11.00	1.10	0.9414	1.0355		
				1.0748	30
11.30	1.20	0.9458	1.1350		
				1.1196	60
12.30	1.15	0.9458	1.0877		
				1.0134	45
13.15	0.80	0.9380	0.7504		
				0.8520	30
13.45	0.65	0.9284	0.6035		
				0.8967	30
14.15	1.00	0.9148	0.9148		
				0.7019	30
14.45	0.90	0.8955	0.8060		
				0.6380	75
16.00	0.60	0.8080	0.4848	—	—

Total for the day

2

temp. θ_2, and the instantaneous collection efficiency η on 14 June, 1979

seed loaded cabinet dryer in series =2.82 kg per min.)

Insolation on heaters during interval $\overline{H}_T . A . \Delta t$ (kcal)	Outlet Temp. θ_2 (°C)	Inlet. Temp. θ_1 (°C)	Temp. Rise $\theta_2 - \theta_1$ (°C)	Heat gained by Air during the Interval $\overline{\dot{m}} . \overline{c} . (\overline{\theta_2 - \theta_1})$ (kcal)	Collection Efficiency (%)
7	8	9	10	11	12
	90	30	60	—	—
2814.79				1364.58	48.5
	96	30	66		
3308.91				1459.06	44.1
	100	31	69		
6893.67				2890.71	41.9
	96	31	65		
4679.82				2213.67	47.3
	104	32	72		
2622.99				1547.37	59.0
	105	33	72		
2729.82				1225.26	44.9
	74	32	42		
2160.89				915 86	42.4
	75	32	43		
4910.41				2076.20	42 3
	66	32	34	—	—
30121.30				13692.71	$\overline{\eta}$ = 45.5

A convenient parameter for comparison of performance of solar collectors is the mass flow rate per unit capture area. Table 3 sets out comparative data which shows that flat plate collectors approach the collection efficiencies of packed bed type collectors only at much higher mass flow rates per unit capture area and at such smaller temperature rises. Improved film heat transfer between the absorber shavings and the flowing air, due to the turbulent character of flow in the packed bed type absorber, is expected to keep "plate" (or absorber) temperatures, and hence heat losses, lower than those with a flat plate type absorber, for a given mass flow rate and solar insolation.

Table 3

Comparative performance of packed bed type and conventional flat plate type solar collectors

Type of solar air heater	Reference	Mass flow rate per unit area of absorber (kg/min m^2)	Maximum temperature rise $\theta_2 - \theta_1$ (°C)	Instantaneous collection efficiency (%)
Packed bed absorber type	Present report	0.27–0.28	72°	42.3–48.5
	,,	0.53–0.54	51°	50.9–71.7
Flat plate type	Johray & Jegadish	0 26	77°	30–34
	,,	1.10	30°–40°	60–70
Flate plate type	(Garg *et al.*, 1981)	2.79	8.6°	45–62

Further experiments are in progress with the following improvements :

(i) Using an instrument for direct measurements of solar insolation on the tilted solar air heaters, to obviate the need for applying angular corrections to pyrheliometer readings obtained for a horizontal surface.

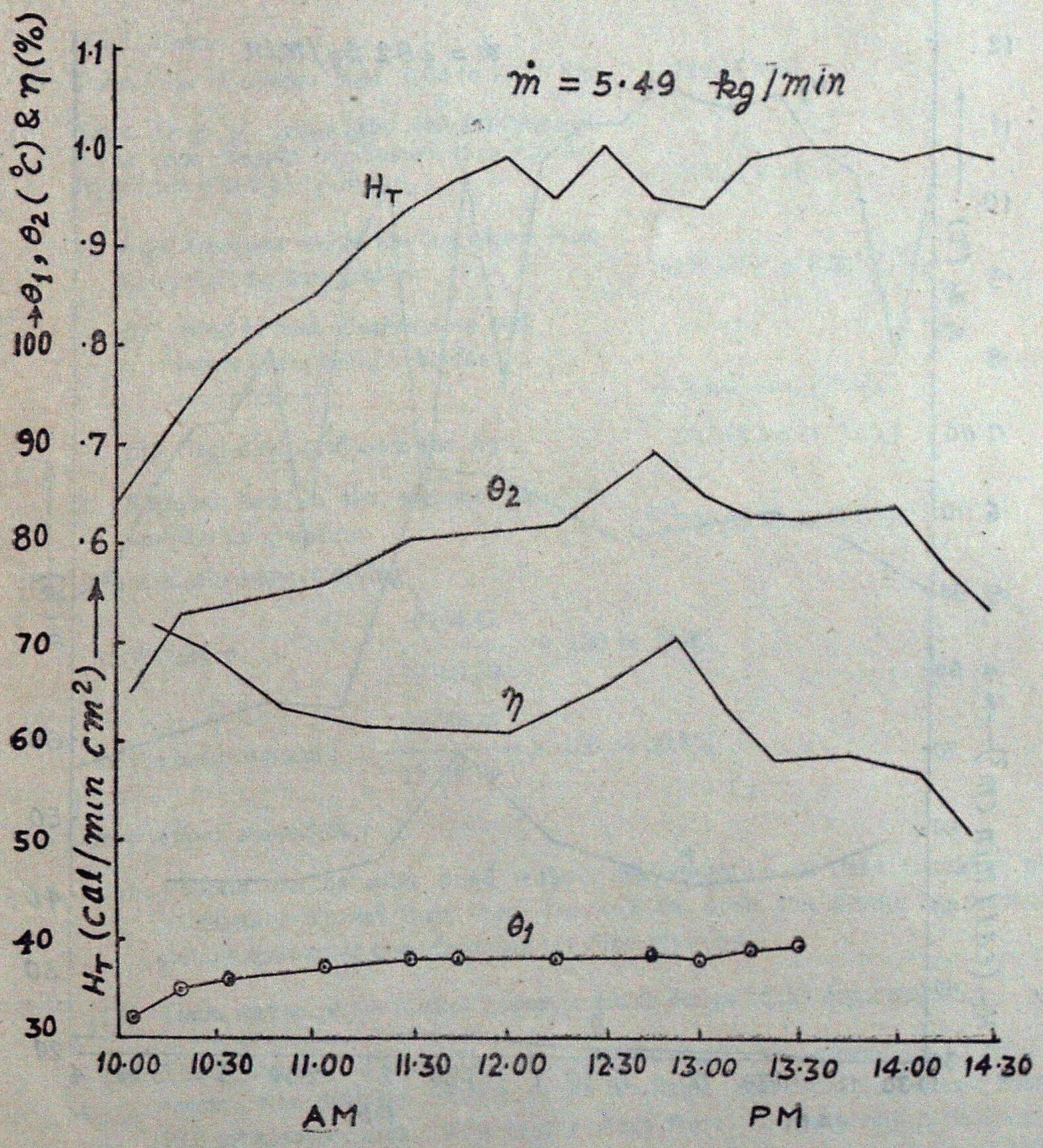
(ii) Using double instead of single glass covers, with a view to further reduce thermal losses from the solar air heaters.

Drying data

(a) *Veeners :*

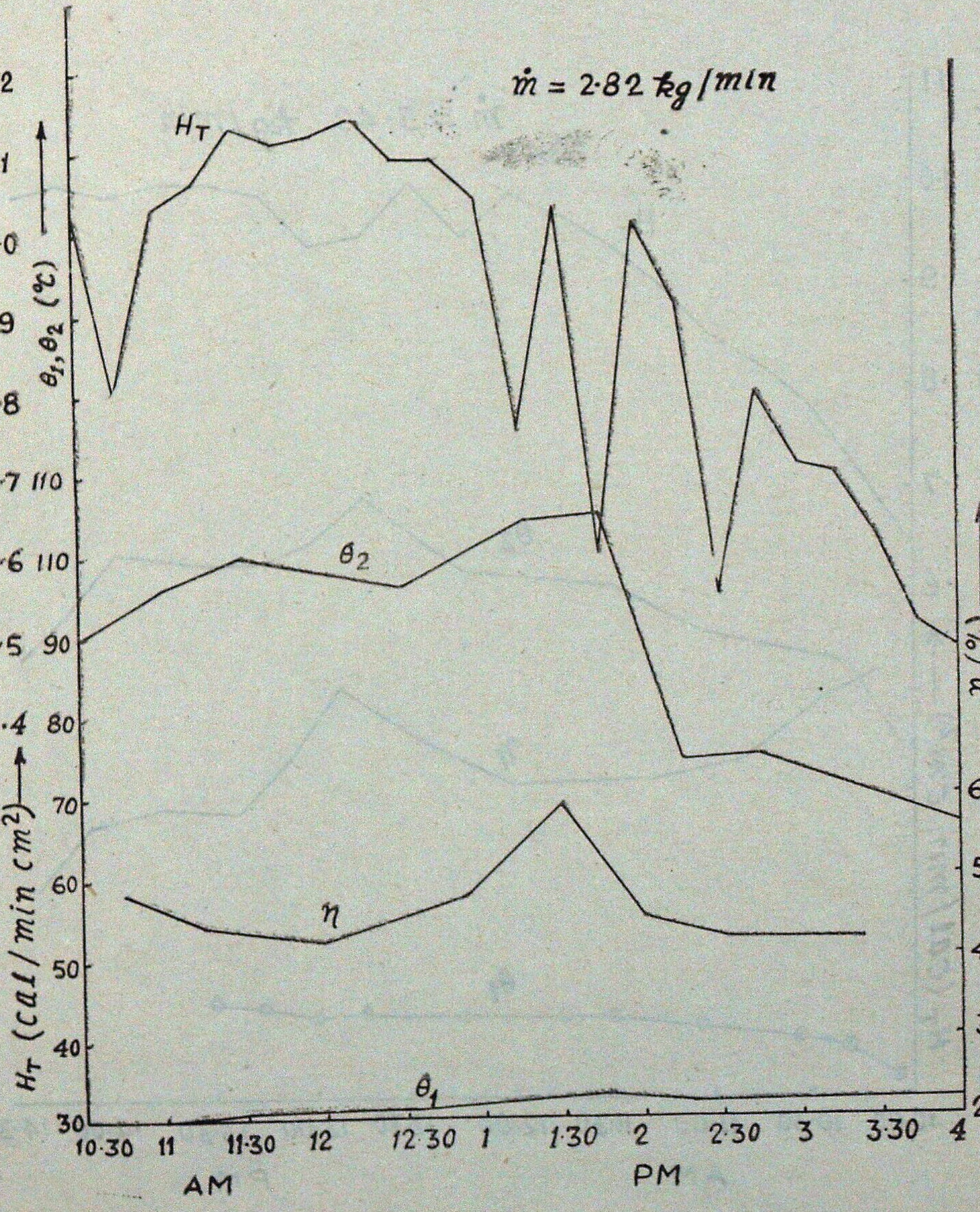
Quantity charged — 50 nos 82.5 × 82.5 cm sheets or 34 m^2 of 2 mm thick green fir veneer .

Fig. 3



Diurnal variation of H_T, θ_1, θ_2 and η on 26 April, 1979.

Fig. 4



Diurnal variation of H_T, θ_1, θ_2 and η on 14 June, 1979.

Initial moisture content	84.6 – 92.1%
Final moisture content	7.4 – 8.4%
Drying time (10.04—13.30 hrs)	3 hrs 26 min
Total evaporation W	16.750 kg

Heat balance

(A) Total solar insolation from 10.04 to 13.30 hrs	19199.12 kcal
(B) Total input of excess heat over the ambient in the solar heated air passed through the dryer from 10.04 to 13.30 hrs	12260.31 kcal
1. Heat absorbed within the dryer from inlet to exhaust air temperature	10070.40 kcal (82.1%)*
(i) Total of heat of adsorption and latent heat (useful heat) for evaporation	9764.42 kcal (79.6%)
(ii) Heat dissipated from the dryer	305.98 kcal (2.5%)
2. Residual heat in the exhaust air over ambient temperature	2239.80 kcal (18.3%)

(C) Thermal efficiency of drying

In the dryer : $\frac{9764.42}{12260.30} \times 100 = 79.6\%$

In the entire system : $\frac{9764.42}{19199.79} \times 100 = 50.8\%$

(a) *Observations showed that*

(1) Veneers can be solar dried without discolouration or defects, taking periods considerably shorter than those required for open sun drying as practiced in cottage scale units manufacturing tea chest plywood.

(2) There was scope for further improvement in design of the dryer section.

(3) The drying load of two stickered stacks of veneers, each containing 17 m² of green veneer, was deficient relative to the available heat from the four air heaters of 10.3 m² absorber area, This was evident from the temperatures in the exhaust air from the dryer, which varied from 46°C to 63°C except during the initial 1½ hrs when the veneer was ringing wet.

*Percentages relative to total heat input at B

(4) It is considered that one more stickered stack of 17 m^2 of veneer could be added along the air traverse length of the dryer for complete utilization of available heat from the four air heaters.

(5) Drying can be programmed in a progressive manner, fully dried stacks being periodically unloaded from the "hot" end of the dryer and fresh green stacks being charged at the "cold" end, with the line of stacks being periodically moved forward.

(6) With such a progressive drying system, it is also feasible to use solar air heaters to supplement conventional modes of indirect heating of the input air by steam or by flue gases produced in a wood burning furnace. High thermal efficiencies at considerably reduced heating costs should result in such a system.

(7) It is estimated that two charges of green 2 mm veneer could be dried per day (reckoning sunshine hours only) using the four heaters, i.e., about 100 m^2 of veneer per day. The output could be further increased, if only veneers partially pre-dried in the open sun or in a simple "fan air dryer" are charged into the solar dryer.

(b) *Sal seed*

In three runs made during June, 1979, the following observations were made :

(1) Seeds took excessively long, about 1½ days (9 sunshine hours), if solar dried with the wings on.

(2) 1½ hrs preliminary solar drying enabled convenent de-winging of the seeds by manual means, as the wings dried and became brittle very quickly.

(3) The seed proper (de-winged) dried much more slowly, but its solar drying to about 14% moisture content could be completed in further 1½ hrs. The total time required including preliminary drying, dewinging and final drying is 6¼ hrs.

(4) The total evaporation from 28 kg of seed during a day (6 sunshine hours) without complete drying was only 6 6 kg which is much less than that obtained from 34 m^2 of green veneer, i.e., 16.75 kg in 3 hrs 26 min. The seed is appreciably slower drying. The exhaust air temperatures from the dryer with 20.5 kg of dewinged seed ranged from 46°C to 63°C, which indicates that the charged seed load was deficient relative to the capacity of the solar air heaters.

(5) It was judged that while the drying load of about 28 kg almost fully matched the heating capacity of the four heaters for preliminary drying of green seed (with wings) to a condition fit for dewinging, the equivalent drying load of dewinged seed could be further increased in excess of 20.5 kg for dewinged seed dries comparatively more slowly. Further experiments would be necessary to establish the optimum drying load of dewinged seed to match the capacity of the heaters.

(6) From the point of view of economical utilization of available solar heat, and for minimizing the requisite total solar absorber area for a given output of dried seed,

it would be desirable to instal two independent drying chains-one for preliminary drying of green seed before dewinging and another for complete drying of dewinged seed. This is in view of the vast difference observed in the rates of drying of wings and seeds.

(7) The discharge air temperatures from the solar air heaters can be easily reduced, if necessary, by providing fresh air intakes with adjustable dampers in the inlet duct to the dryer section.

(c) *Dhak leaf*

Only three runs were made. The following general observations were noted :

(1) The normal 50-leaf bundle is suited only for the slower open sun drying method being adopted by village harvesters. It is too big for accelerated solar drying. Leaves in the centre of bundles were found wet even after 2 days drying (11 hrs, 5 min sunshine hours only) in the solar dryer. Exhaust air temperatures from the dryer varied from 50°C to 56°C, except during the first 2 hr, 5 min of drying in which they were lower, indicating that available heat was not fully utilized in the dryer because of the slow rates of evaporation from the interior of thick bundles.

(2) The 25-leaf bundles needed 2 days (11 to 12 sunshine hours) for complete solar drying. The exhaust air temperatures from the dryer varied from 50°C to 55°C, except during the first 6 hr, 45 min in which they were lower. The comparatively longerinitial period in which temperatures kept lower were indicative of better heat utilization with comparatively thinner bundles.

(3) The 10-leaf bundles could be fully solar dried within about 6½ hrs. The dryer exhaust air temperatures ranged from 50°C to 67°C except during the first 2½ hrs. It is indicated that more drying load of 10-leaf bundles could be added to completely utilize the available heat. Further experiments with 10-leaf bundles would be necessary to establish the matching drying load.

Conclusions

Comparatively cheaper and lighter design of packed bed absorber type solar air heaters than the conventional flat plate absorber type have been developed and tested. Four such air heaters in series, with total collection area of 10.3 m^2 in a length of about 11 m. are able to give delivery air temperatures between 65°C and 89.5°C at delivery rate of 5.49 kg per min on clear days in April at Dehra Dun, with an average solar collection efficiency of 62 per cent. Higher delivery temperatures between 66°C and 105°C could be obtained on a clear June day with reduced delivery rate of 2.82 kg per min, at an average collection efficiency of 45.5 per cent. Experiments need to be extended to examine whether still better collection efficiencies could be achieved by using double instead of single glass covers and "booster reflectors" for trapping more of solar insolation. Instruments for direct measurement of insolation on tilted surfaces should be employed for better accuracies in future experiments.

The solar air heaters system described in this report has appeared to be best suited for drying of veneers, and similar sheet and strip materials like hand-made paper and wood wool, in which resistance of the material to diffusion of moisture does not limit the rate of drying. It is estimated, based on the heat balance data presented, that 10.3 m^2 of collector area of such heaters would match a dryer load of about 51 m^2 of green 2 mm thick veneer, giving an output of about 102 m^2 of fully dried veneer per day (in two charges daily) during summer months at Dehra Dun (30°N). A progressive drying system, using suitable time-based schedules for each species and thickness of veneer, can be adopted. Combined with partial fan-air predrying, using unheated atmospheric air, the above mentioned collector area could serve for still greater output of dried veneer. The solar air heaters system also offers the possibility of supplemental solar heating of steam heated veneer drying tunnels of the progressive type.

The potential of the solar air heaters system has also been demonstrated for drying of seed and bidi leaf bundles, though major modifications may be necessary from the dryer designs used in the present investigation for products for which optimum drying temperatures happen to be considerably lower than the delivery air temperatures obtainable from the air heaters.

At the available high air temperatures (65°C–105°C), the best procedure for sal seed drying appeared to be to instal two solar drying chains, one for preliminary drying which facilitates dewinging and takes only about 1½ hrs. and the other for final drying of the dewinged seed which takes a furthur about 4½ hrs. For a proper seed dryer design, it has been established that 10.3 m^2 of collector area of solar air heaters would match preliminary drying requirements before dewinging for about 28 kg of green whole seed (with wings) in a charge, the average charge time being about 2 hrs. The matching dryer load for final drying of dewinged seed would need to be established by further experiments, but would be more than 20.5 kg.

In case of dhak leaf bundles it was found not possible to achieves short enough drying times, even at the available high air temperatures (65°C–105°C), except when the bundle size was reduced from the usual 50–leaf size. In the 10–leaf bundles drying could be completed within 6½ hrs during the pre-monsoon month at Dehra Dun. With regard to dryer design for leaf drying, indications have been obtained that the matching dryer load of leaves for a 10 3 m^2 collector area of solar air heaters would be appreciably more than 900 10-leaf bundles. The economics of this method of solar drying of leaf bundles at high drying temperatures needs a special field study, as the present method of open sun drying of leaf bundles only involves manual labour for arranging the bundles on ground and turning them over every day for about 8 days, and leaf collection and drying are done in areas where labour is cheap. The saving of wastage of leaves through discolouration of the top and bottom leaves in each bundle, loss by being carried away by wind, and occasional spoiling of the seasons last week's harvest during open sun drying due to early onset of rains should however be reckoned for a strong case in favour of solar drying of leaves.

Pilot field trials would need to be conducted on solar drying of the above products to investigate its economics under commercial conditions though rough estimates are possible from the data presented in this paper.

SUMMARY

Packed bed type solar air heaters having total collector area 10.3 m² in 11 m length have been found to yield maximum outlet air temperatures between 90°C and 105°C during April to June at Dehra Dun at air mass flow rates between 2.77 and 5.54 kg/min. Average diurnal solar collection efficiencies varied between 45.5 and 62%.

It is established that temperatures suitable for accelerate drying of veneer, sheet materials, wood wool and minor forest produce on a cottage or small scale can be easily and cheaply achieved by these solar air heaters. A 10.3 m² collector area has been estimated to suffice for a charge capacity of 51 m² of 2 mm thick green veneer (charge time 3½ hrs), somewhat more than 28 kg of sal seed (charge time 6½ hrs), and more than 900, 10-leaf bundles (charge 6½ hrs). Possibilities of supplemental solar heating of existing steam heated dryers by this system also exist.

सौर ऊर्जा द्वारा काष्ठ अन तथा गौण वनोपज को सुखाने की सुगम रीति का विश्लेषण

लेखक एस०एन० शर्मा, प्रेमनाथ, एस०पी० बडोनी तथा पी०के० जैन

सारांश

संवेष्टित पलंग प्रकार के 11 मी० लम्बाई और कुल 10.3 घनमीटर सँभरण क्षेत्र वाले सौर वायु तापक अधिकतम वहिर्गम वायु तापमान, 90° सें० से 105° सें० तक, देहरादून में अप्रैल से जून के बीच अपनी वायु पुंज प्रवाह दरें 2.77 और 5.54 किग्रा/मिनट रख कर प्रदान करते पाए गए हैं। दिन की औसत सौरताप ग्रहण दक्षता 45.5 और 62 प्रतिशत के बीच रही।

स्थापित यह किया गया है कि परतें, शीट पदार्थ, काष्ठ अन और गौण वनोपज को कुटीर आधार या छोटे परिमाण पर त्वरित गति से सुखाने का कार्य बड़ी सुगमता से और सस्ता इन सौर वायु तापकों से सम्पन्न किया जा सकता है। अनुमान किया गया है कि 10.3 घन मीटर संभरण क्षेत्र 2 मिमी० मोटी, 51 वर्ग मीटर हरी परतों (प्रभरण समय 3½ घंटे) 20 किग्रा० से कुछ ज्यादा साल बीजों (प्रभरण समय 6½ घंटे) तथा 10–10 पत्ती वाले 900 से अधिक बंडलों (प्रभरण समय 6½ घंटे) की प्रभरण धारिता के लिए पर्याप्त रहेगा। वर्तमान भापतापित आपाकों को सौर तापकों से अनुपूरित करने की संभावनाएं भी इस प्रणाली में मौजूद हैं।

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RESEARCH NOTE

Bamboo Flowering—A Rare Phenomenon

Bamboo which is often termed as poor man's timber, belongs to grass family, but unlike other grasses it's growth pattern differs very much. Flowering in Bamboos is a rare phenomenon. Generally it occurs at long intervals. Because of the long gap between two successive flowering of a particular species of bamboos, our knowledge of bamboo flowering is not thorough. However, certain physical characteristic do indicate when the plant is ready for flowering. The top growing point of the bamboo stem goes on growing as such for a long period but after a period a stage is reached when these regions of growth are transformed into reproductive parts. Such conditions are caused partly due to genetics and partly by environmental characters. The hormones play a vital role in such a change. There is great metabolic changes also in the young developing flower centres of the plant in the brief period of floral differentiation. During the process of flowering rate of assimilation is very high and there is continuous movement of food, water, organic and inorganic compounds and hormones towards regions of reproductive growth. Bamboos develop from a underground rhizome and as it grows it goes on giving out new shoots. Each shoot is called as *Culm* and a group of these bamboos from the same rhizome is called as *Clump*.

Distribution and Type

Bamboos are found in all the tropical and sub-tropical regions of the world specially in Asia and South America. Gamble has enumerated 115 species of bamboo occurring in India, Pakistan, Burma and old Malaya.

Symptoms

Although symptoms of flowering are not very discernable, but field experience of forestry and especially that of working in bamboo forests, do show some indicative characteristics by which one can visualise the apparent changes that the bamboo culms undergo. Some of the significant points are :

(i) The branches tend to be stunted and bushy.

(ii) In general production of new shoots stops.

(iii) Colour of the stem becomes dull and all freshness and vigour disappears thereby giving an overall sickly look to the clump.

(iv) In several cases yellow/whitish vertical streaks develop on the stems.

Flowering is generally preceded by leaf fall and after seed formation the culms die. All the culms (Single Bamboo) of a clump, flower simultaneously, but there are instances

when only a few of the lot have flowered and died and nature has temporarily spared the life of others.

Mass Flowering

Bamboos are now under flowering in Chandrapur district in the eastern part of Maharashtra State. Bamboo occurs naturally in the extensive forests of this district Before its bifurcation in 1982, this was the biggest district in Maharashtra, covering an area of 26128.7 sq. kms. Out of this nearly 66% of the area is covered under forest to the extent of 17325.78 sq. kms. Mass scale flowering is now occurring in the bamboo forest of West Chanda and part of central Chanda division, falling under the revenue tehsils of Chandrapur and Rajura. Approximately an area of nearly 1250 sq. kms of bamboo is affected.

Death

The exact reasons of mass dying of bamboos, after they have flowered is still not very clearly known. Certain researches have pointed out that the reason may be due to sudden loss of all the stored food which is consumed in flowering and fruiting resulting in sheer exhaustation of the culms. Almost all the bamboo species die in the year of flowering except *Bamboosa arundinacea* where flowering continues for 3 years and then the culms die.

Mass Flowering of bamboos is associated with famine and drought Due to very large amount of seed available, the population of rats increase in the forest tremendously. Thus in the early part of this century and also in the last, flowering of bamboos was also associated with deadly disease like plague. Thus mass flowering of bamboos generate some fear in the Forest & rural dwellers.

Utilisation

The estimated annual production of bamboos in Maharashtra is about 1,45,000 tonnes. Out of this, approximately 1,30,000 tonnes is being availed of by Paper Industries alone. Chandrapur district contributes nearly 83% of the total supply of bamboos. Thus gregarious flowering assumes a very significant and important aspect from the availability of raw material point of view, to the paper industries and may have a serious effect on the production of paper. Bamboos are a source of income to the "Burads", a local artisan, who manufacture baskets, mats and other handicraft article out of green bamboo. But the use is limited. The quantity of material diverted to other uses including to the burads, is about 15,000 tonnes. Since the available quantity of bamboos from the forest of Maharashtra are being utilised fully, and the fact that the demand in future is bound to increase, reliance now is being placed on motivating the private cultivation of bamboos by individuals to supply the demand of raw material in future. Efforts in this direction are on foot by Forest Department to involve individuals in this scheme, especially the farmers by planting bamboos on the bunds of their fields and around their houses and huts.

Management

The scientific management of bamboos in the Government forests undergo a different set of management practices in case of mass flowering. The most critical period is when the seed falls and upto the time when it germinates and establishes as a clump which may take any where between 8 to 10 years During this period the bamboo forests are rigidly fire protected as the seeds and tender bamboos are very much susceptible to fires. Any fire whether ground or crown, will cause extensive damage to the plants. The dead and dried clumps are a great potential fire hazard. Thus fire protection is of utmost importance. The new seedlings establishes after it produces a small "Knot" or rhizome In later stages this rhizome which is under the ground, expands and throws up a number of shoots or culms which on maturity after 8 to 10 years, are harvested as bamboos. Sometimes the natural seedlings in the forest are also augmented by planting artificially. The bamboo seedlings raised in nurseries or planting carefully the rhizomes dug out from other forest areas The aim is thus to restock the area completely. Further, protection from grazing of cattle is also to be strictly affected In many parts the tender shoots are used by local people specially the Adivasis for eating purpose.

Previous record of flowering

The earliest recorded flowering of bamboo in areas now undergoing flowering was in the year 1901. Thereafter the next flowering was recorded in the year 1942. This is now the third recorded flowering of bamboo in the year 1982.

Publicity & Information Officer, S.A.H. Quereishi
Forest Department,
Pune-411011 (Maharashtra)

— —

LETTERS TO THE EDITOR

(I)

To,
The Honorary Editor,
Indian Forester,
P.O. New Forest, Dehra Dun

Sub. : **Pollarding in *Diospyros melanoxylon* Roxb.**

Sir,

Pollarding consists of topping a pole tree at a height of 4 feet from ground to produce a crown of new shoots from buds below the cut stump.

Experiments of pollarding on *D. melanoxylon* (bidi leaf yielding tree) were performed by Forest Departments of Andhra Pradesh, Maharashtra, Tamil Nadu and Uttar Pradesh, have yielded good quality of leaves in significant amount, from January to March

During the present study it was found that after pollarding the trees in February, the size of newly emerged branch was maximum (104 cm). However the number of newly emerged leaves/stump was increased from 5 (control) to 32 alongwith increase in size from 13 × 7.5 cm (control) to 25 × 13 cm (pollarded). Similar results were also obtained in trees pollarded one month earlier or later. Post-pollarding observations witnessed that the average number of quality leaves per stump was also found to be increased in these months. Percentage of bored and galled leaves was observed maximum in trees which were pollarded in July and December.

The present study reveals that pollarding is found to be suitable for better yield of quality leaves, if performed from January to March. However, it is less successful in comparison to pruning.

Yours sincerely,

Sd./-Dr. C.D. Athaya
Research Associate,
Department of Botany,
University of Saugar, Sagar (M.P.)

(II)

To,

The Honorary Editor,
The Indian Forester,
New Forest,
Dehra Dun.

Sir,

Kindly refer to Shri A.R. Maslekar's letter published in October, 1982 issue of your journal which relates to our paper titled 'Alternative package for apple'. In this connection we wish to inform as under.

(1) We agree with the requirements of fruit packing cases given in the letter. Most of the requirements are given in the paper titled 'Apple Packing—A challenge' by Shri N.K. Shukla which was last paper under reference.

(2) Regarding cost of production, as the veneers were not procured from the market and perhaps fir veneers, preferred for the purpose are not available in the market because of lack of demand, it is not possible to assess accurately the cost of alternate boxes.

(3) As regards assumption, presently wood is available at cheaper rates to the conventional wooden apple box manufacturers and assumption is that wood will be available to the suggested veneer box manufacturers too at cheaper rates.

(4) The extra costs involved in the manufacture of veneer boxes as compared to conventional wooden boxes are labour, kraft paper and additional investment for a peeling lathe for the production of veneers. They are estimated to be Rs. 1/- each for labour and kraft paper per box. The approximate cost of smallest peeling lathe is Rs. 30,000.

(5) As there is about 50% savings in timber consumption per box i.e. from the amount of timber presently used for making the conventional wooden boxes we can make about double number of veneer boxes. Even if all the saving in cost because of the saving of timber is spent for increased cost of labour etc. the alternate boxes should be preferred.

(6) Costlier the wood cheaper will be the alternate boxes suggested in the paper.

Yours faithfully,

Sd./- R C. Tandon
Senior Research Officer,
Timber Mechanics Branch,
F.R.I. & Colleges, Dehra Dun

NEWS & NOTES

World Congress of Herpetology

By recent action of the officers and official representatives of the major national and international herpetological societies, an international committee has been established to plan the first World Congress of Herpetology. The congress will be held in 3–5 years at a site yet to be selected. The Planning Committee consists of :

Donald G. Broadley (Zimbabwe)
Harold G. Cogger (Australia)
J. C Daniel (India)
Ilya S. Darevsky (U.S.S.R.)
Marinus S. Hoogmoed (Netherlands)
Toshijiro Kawamura (Japan)
Michael R. K Lambert (U.K.)
Hubert Saint Girons (France)
P. E. Vanzolini (Brazil)
David B. Wake (U.S.A.)
Kraig Adler (U.S.A.), *Secretary-General*

The congress will be organized to include a wide range of topics, to appeal to all persons interested in the scientific study of amphibians and reptiles. The committee currently is setting guidelines for operation, including the establishment of a larger and broadly representative International Herpetological Committee to provide a self-perpetuating mechanism for future congresses.

The Planning Committee solicits comments from the herpetological community on all aspects, in particular the choice of a convenient site and content of the congress. Potential hosts for the congress are also invited to communicate. Fur.her announcements will be published in this journal.

Address comments or questions to any member of the Planning Committee or to the Secretary-General : Professor Kraig Adler, Cornell University, Section of Neurobiology and Behavior, Seeley G. Mudd Hall, Ithaca, New York 14853, U.S.A.

GAZETTE NOTIFICATIONS

F.R.I. GAZETTE

1. Consequent upon his selection to the post of Scientist 'SD' (Forestry) at Space Appplications Centre, Indian Space Research Organisation, Ahmedabad, the President, Forest Research Institute & Colleges, Dehra Dun has been pleased to relieve Dr. V.K. Srivastava, Research Officer, Forest Ecology Branch with effect from 31.1.1983 (A.N.).

2. The President, Forest Research Institute and Colleges, Dehra Dun has been pleased to accept the resignation tendered by Shri T. Krishnamurthy, Research Officer, of his appointment under Forest Research Institute & Colleges, Dehra Dun with effect from 11.3.1983 (A.N.).

ANDHRA PRADESH GAZETTE

On repatriation from the Andhra Pradesh Industrial Development Corporation, Shri K. Kesava Reddy, IFS., the Conservator of Forests is posted as the Conservator of Forests, Logging Project Circle, Rajahmundry relieving Shri T.V. Rangarajan, IFS., the Conservator of Forests, Guntur Circle of the additional charge.

KARNATAKA GAZETTE

On completion of their training the following Indian Forest Service Probationers are appointed with immediate effect and until further orders to the post indicated against each :

	Name of the IFS Probationer	Place of posting
1.	Shri Ravi Ralph	Assistant Conservator of Forests, N.R.V.P., Gulbarga.
2	Shri Ashok Kumar Singh	Assistant Conservator of Forests, Dandeli Sub-Division, Dandeli.
3.	Shri B. Shivanna Gowda	Assistant Conservator of Forests, and Assistant to Deputy Conservator of Forests, Karwar Division, Karwar.
4.	Shri R.S. Suresh	Assistant Conservator of Forests, Plantation Sub-Division, Bangalore.
5.	Shri S. Rajanna	Assistant Conservator of Forests, Assistant to Deputy Conservator of Forests, Madikeri Division, Madikeri, vice Shri B. Basheer Ahamd transferred.

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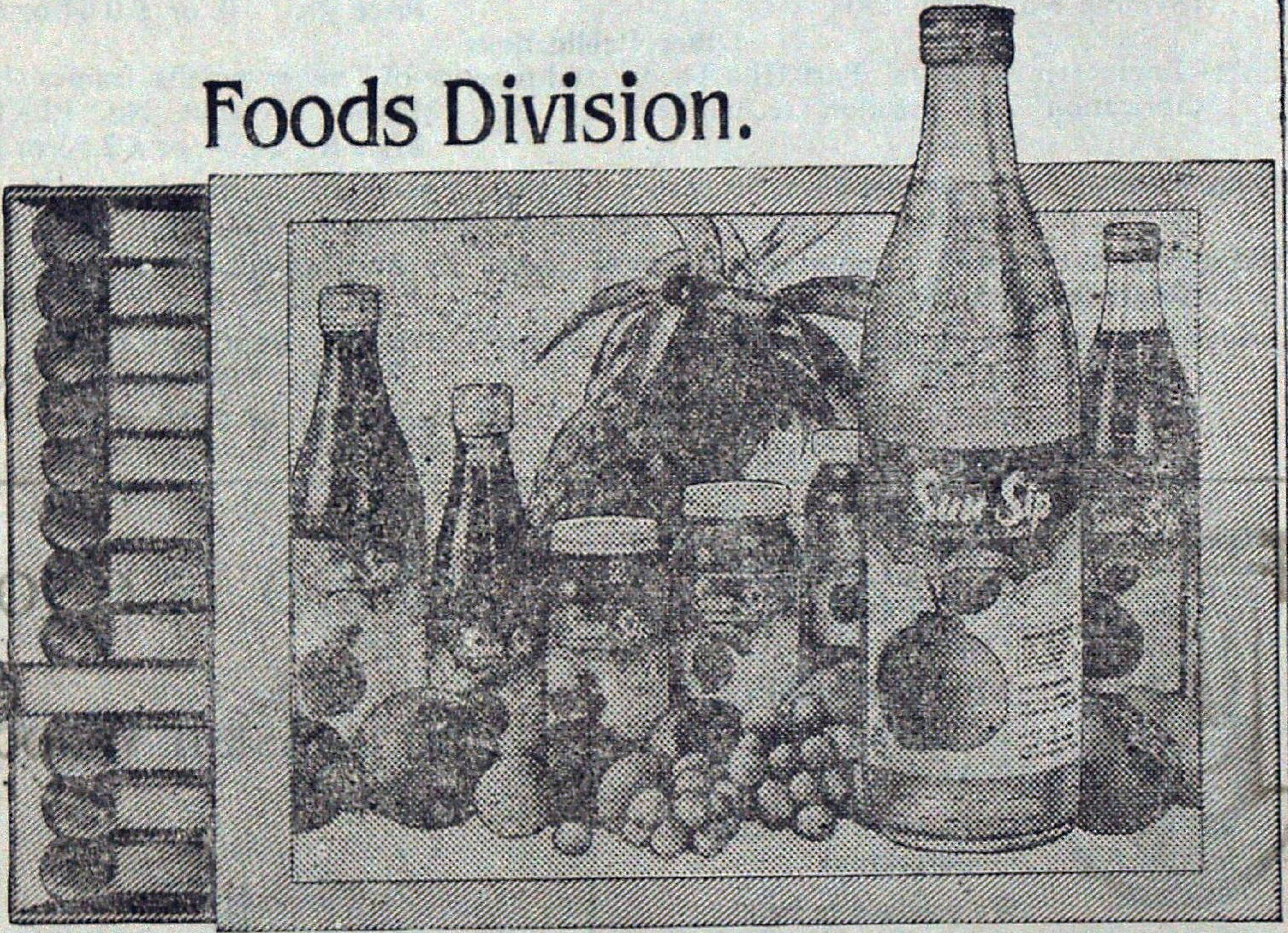

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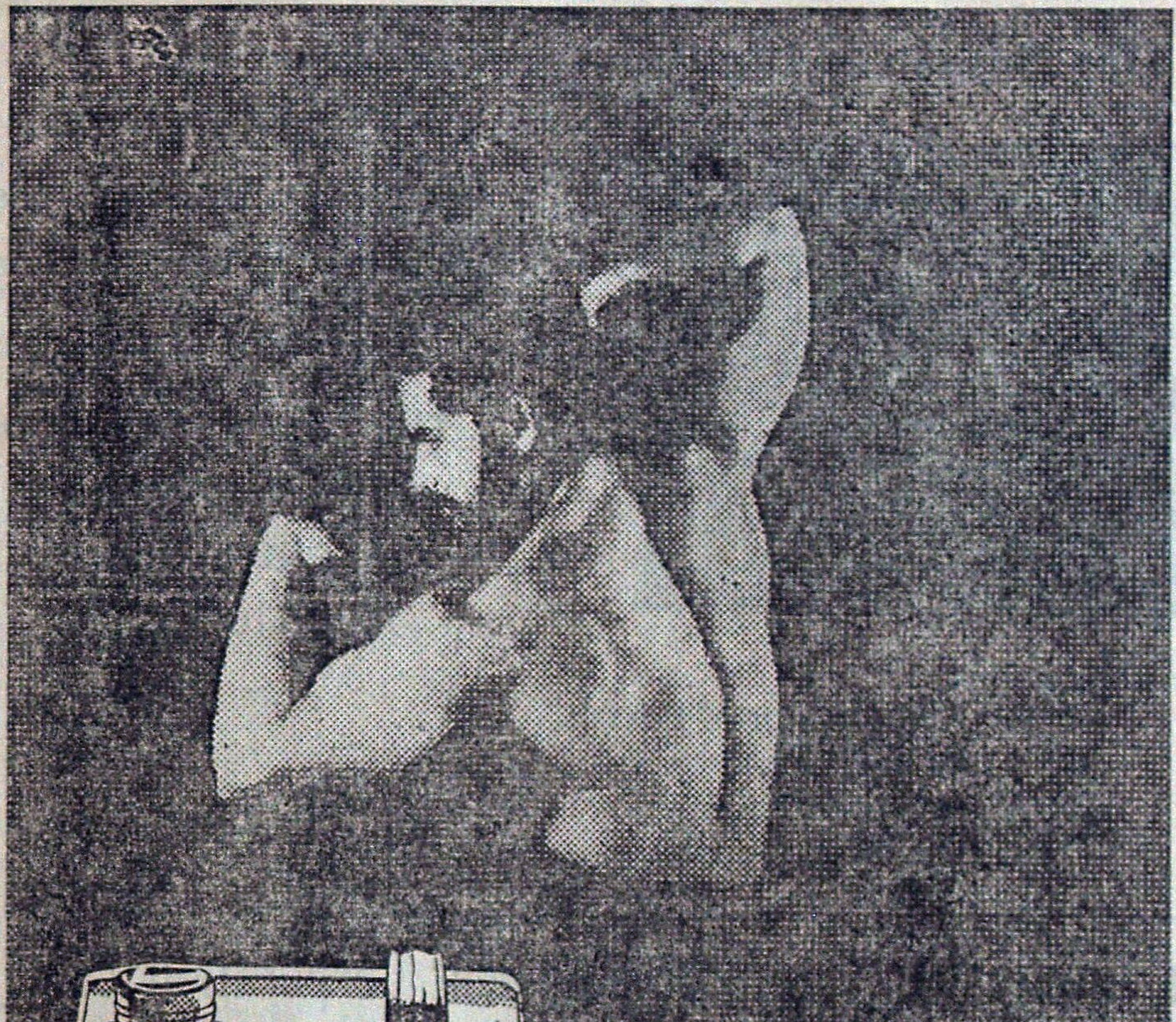
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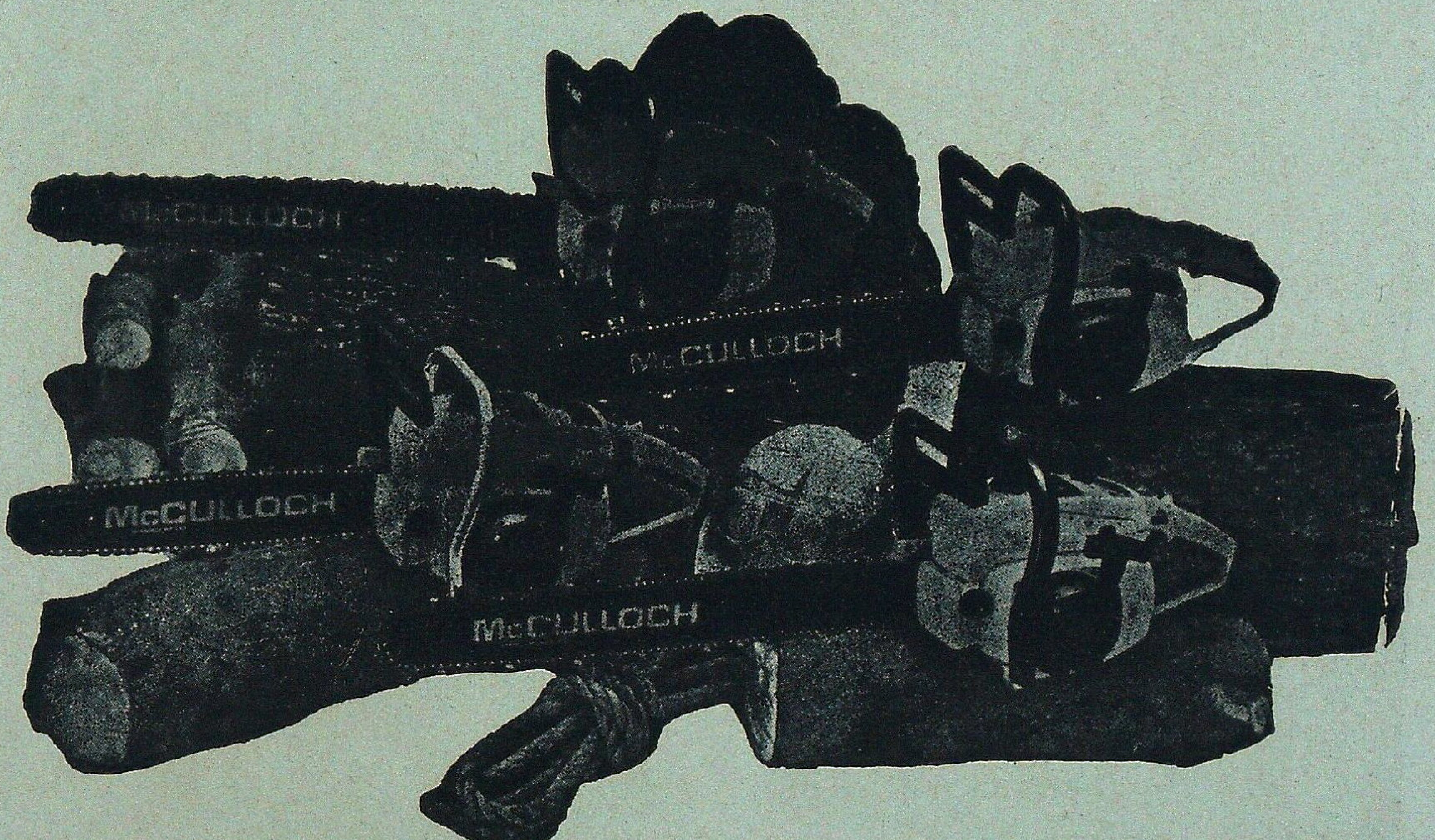

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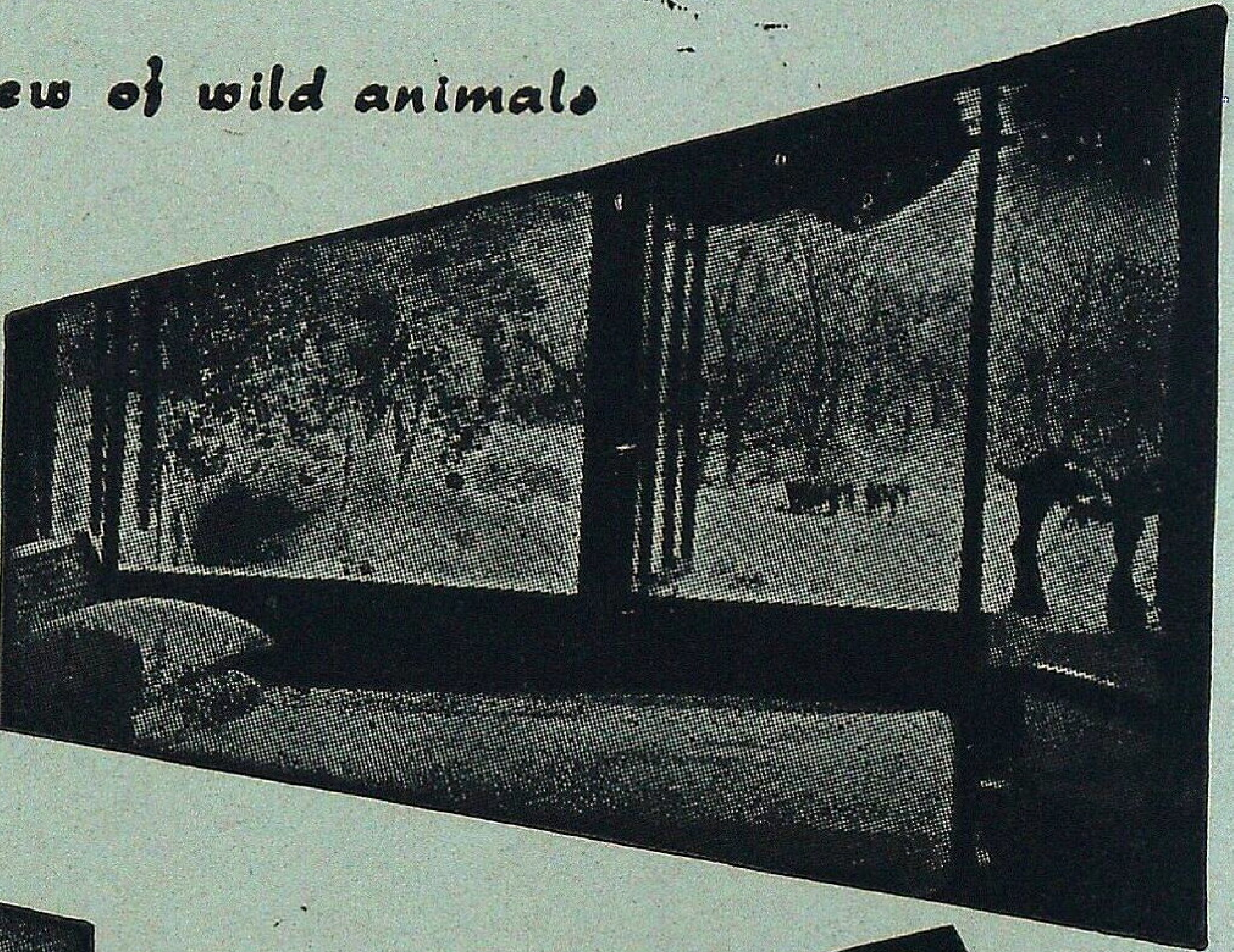

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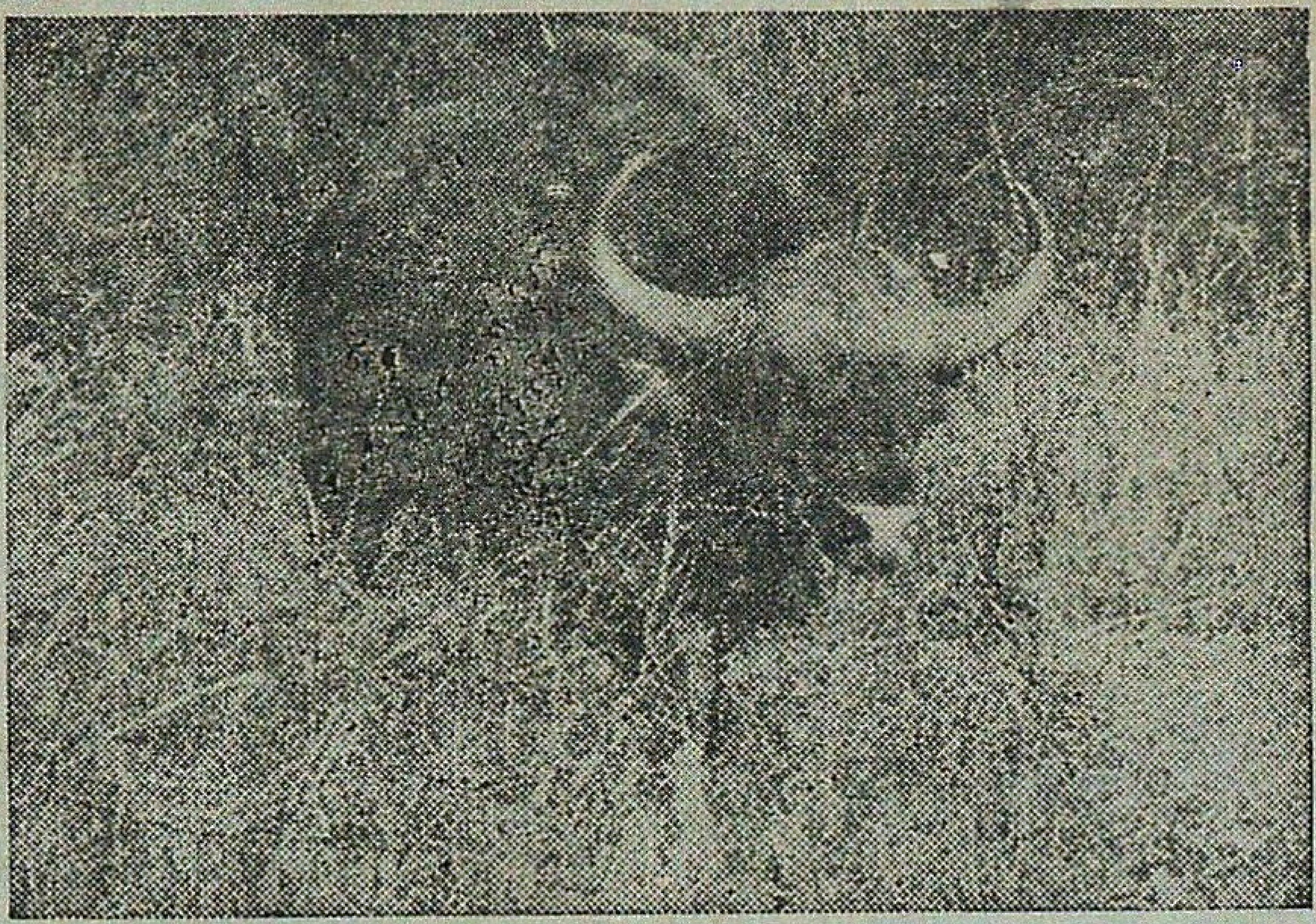

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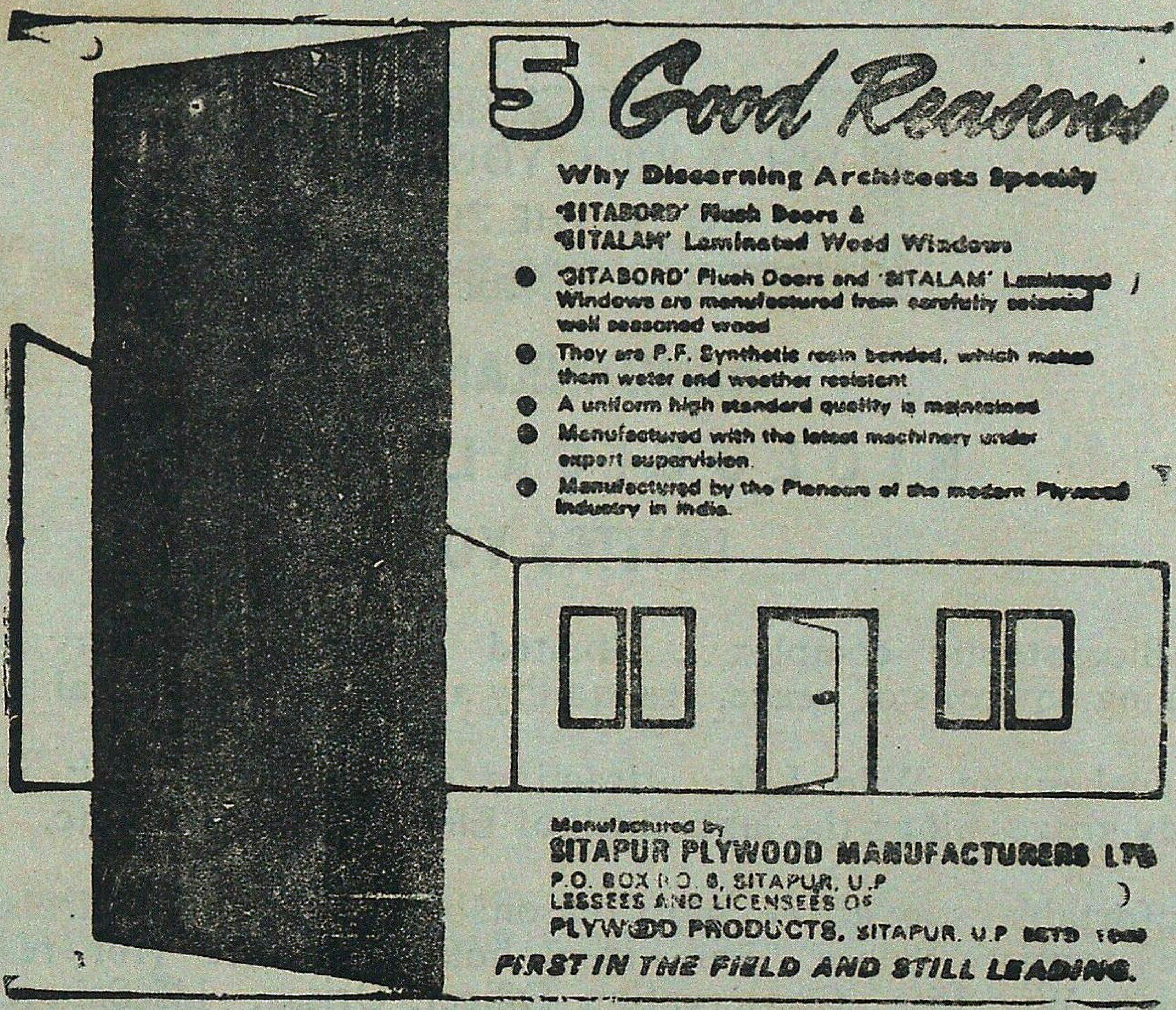

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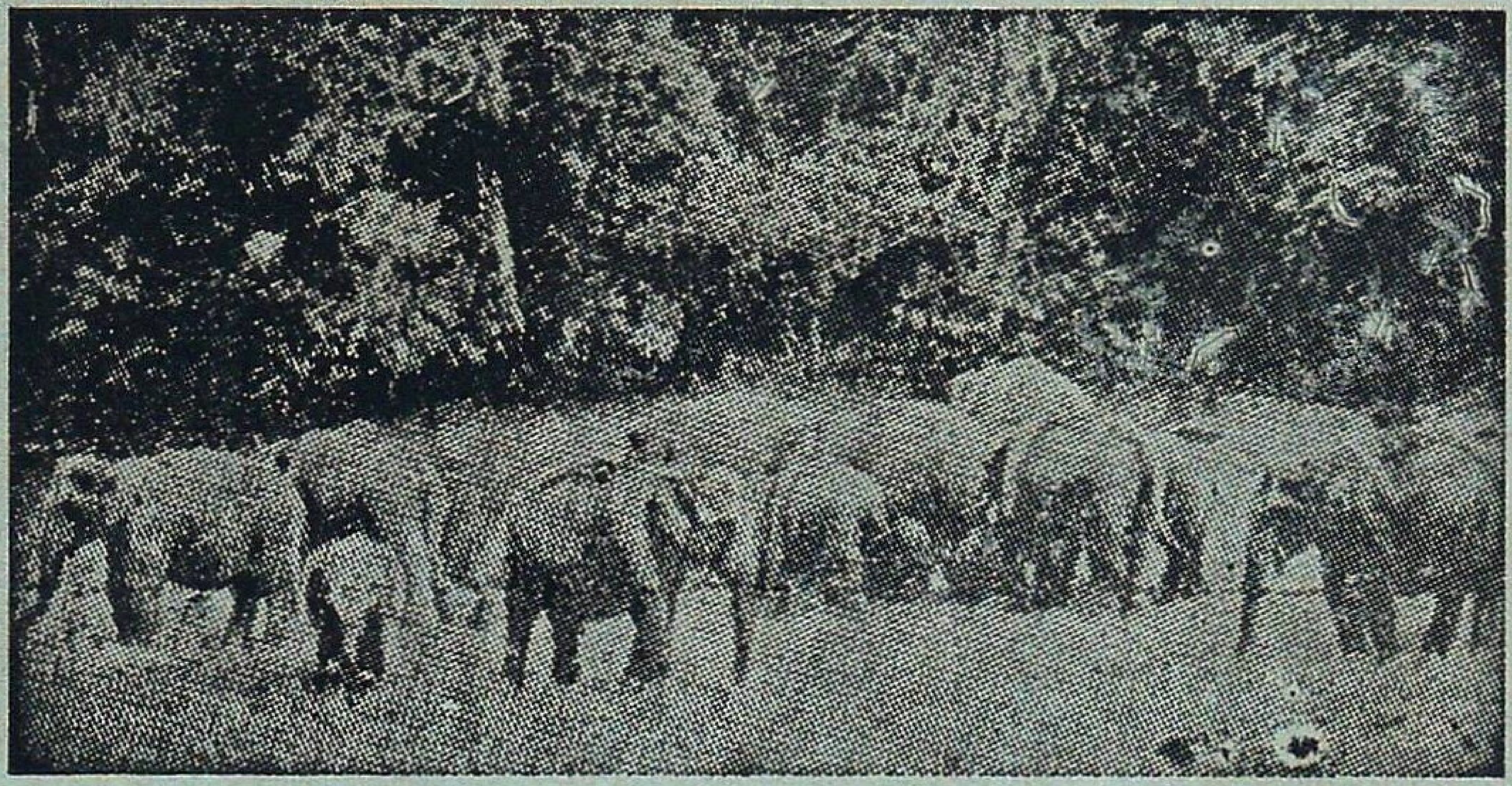

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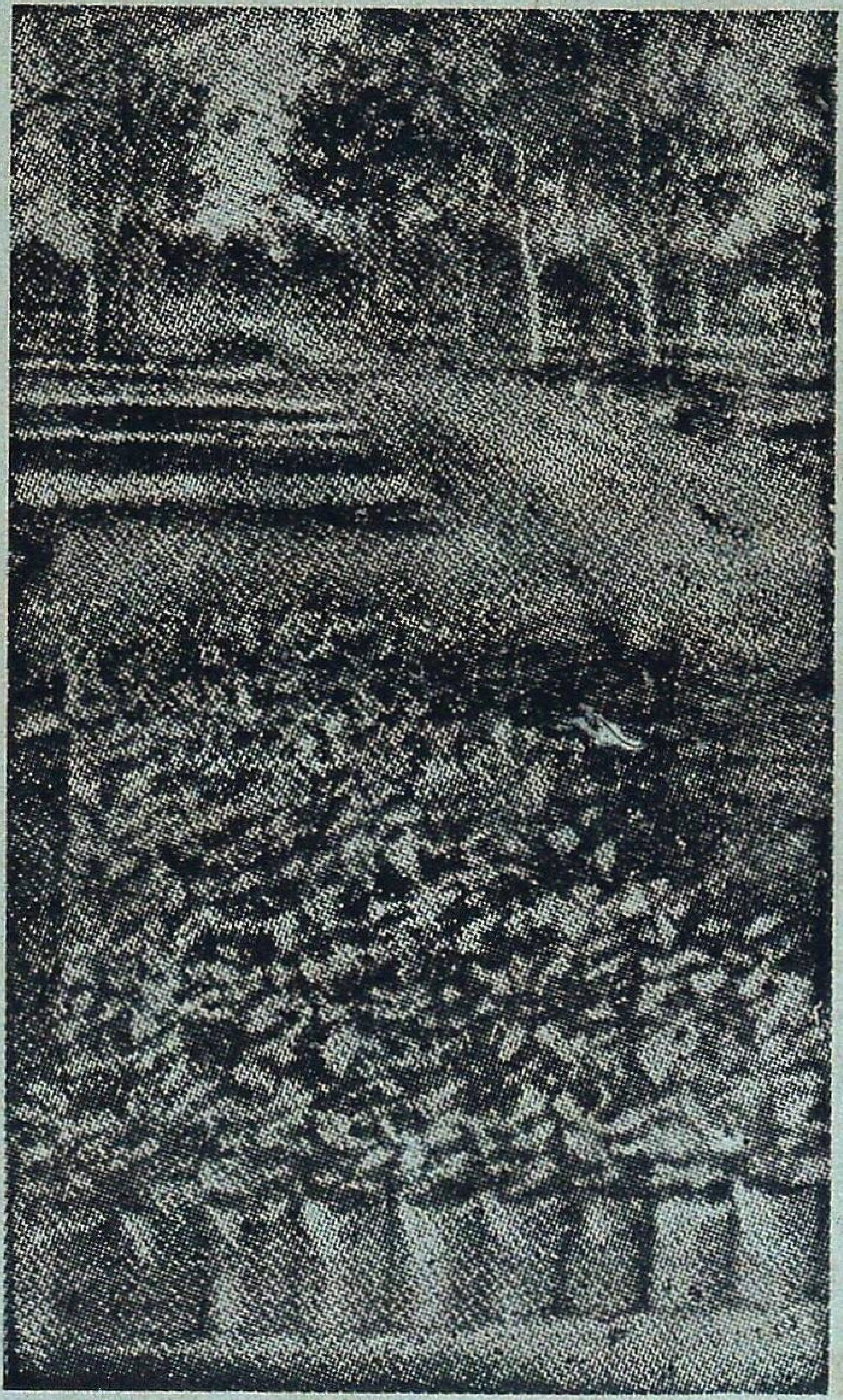

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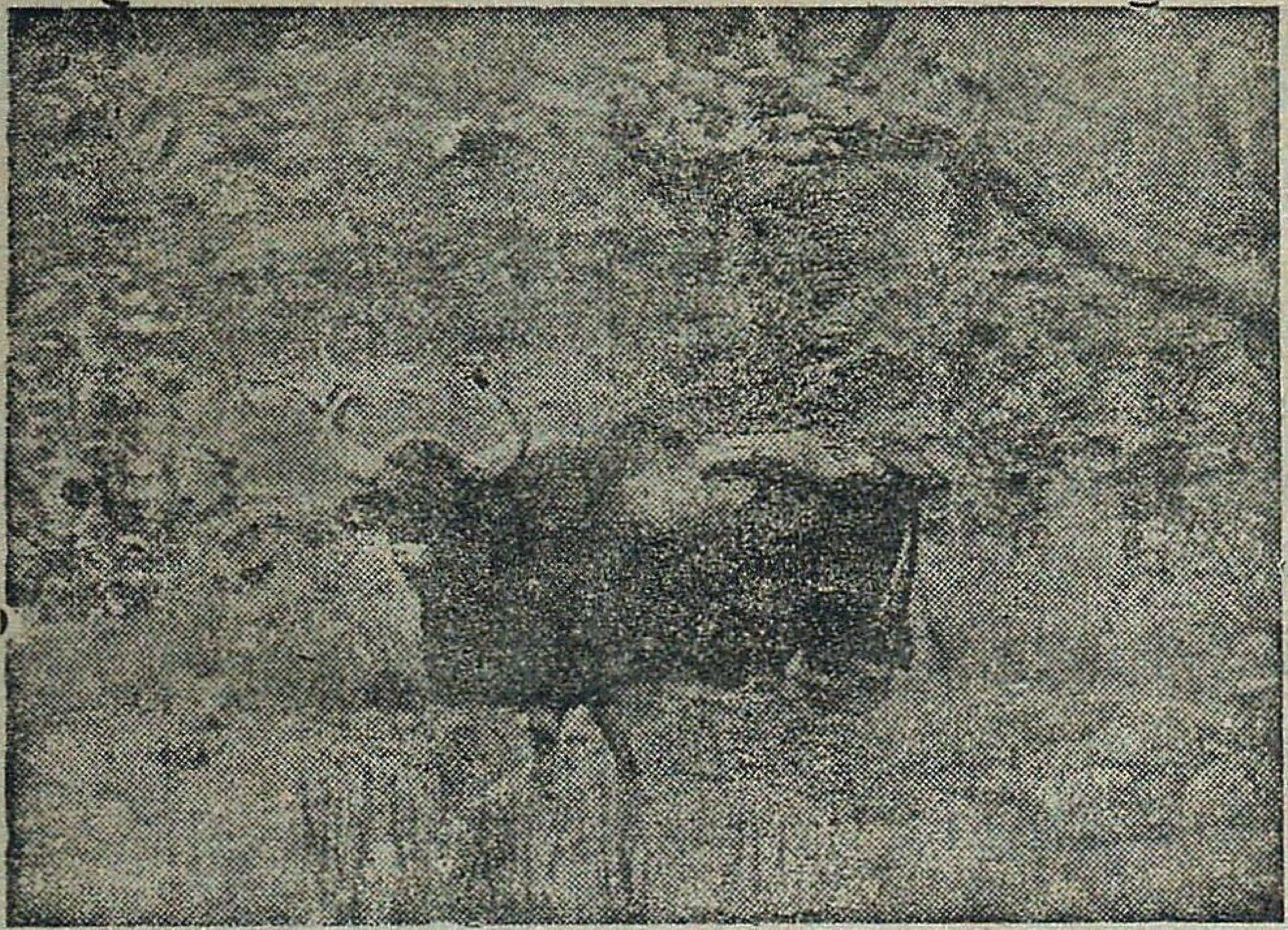

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VOLUME 109 MAY, 1983 NUMBER 5

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